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THE SOUTHWEST AFRICAN RAILWAY.

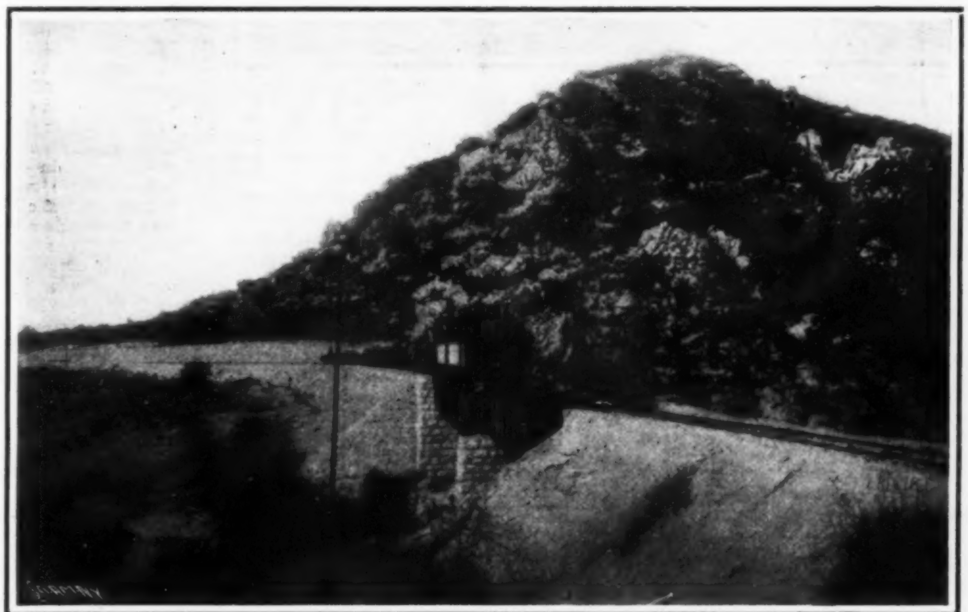
By DR. ALFRED GRADENWITZ.

THE Otavi Railway is about 360 miles in length, and is probably the longest road of its kind in the German colonies. It was constructed by the Arthur Koppel Company for the transportation of copper ores from the Otavi mines to the harbor of Swakopmund. Lately, however, it has been opened to general traffic, and promises to improve greatly the economic conditions of the colony.

Great difficulty was experienced in securing the necessary workmen for the construction of the road. In fact, no sooner had actual work begun, than the Herero uprising of 1903 broke out and put a stop to the operations. Many of the native workmen left, and it became necessary for the German government to take those remaining into custody, so that in May, 1904, the contractors, fearing too great a delay in the completion of the work, decided to import 300 European laborers. In the meantime, the lack of a convenient railway system had been keenly felt by those in charge of the military operations. Transportation had to be carried out (by means of ox carts) under the most unfavorable conditions, and the volume of freight increased so rapidly that this primitive mode of conveyance soon proved inadequate. Therefore, the government, besides requesting Messrs. Koppel to hasten the construction of the railroad, offered a premium for the completion of the road first, as far as Ouguati, 109.7 miles, thence to Karibib, 118.5 miles, and again from Ouguati to Omaruru. As a result, about 500 Orambos and 750 Italians were engaged by the company. The Italian workmen proved very unsatisfactory, availing themselves of the difficult conditions prevailing in the colony to make excessive demands upon the company and to organize unceasing strikes. In the spring of 1905 conditions first began to improve, when, through the granting of premiums to the several construction gangs, the work was pushed forward with great rapidity. Furthermore, the contractors succeeded in inducing many Hereros to give themselves up and accept work on the railway. As the rumor of the excellent working conditions and treatment accorded the laborers spread among the remaining rebellious natives, many others offered themselves to the company as willing to work. Strange as it may seem, these warlike natives proved not only to be excellent workers, but also better-natured and more docile than any other black men employed in railway construction.

The landing conditions in Swakopmund harbor further hindered the company in their work. The import of merchandise had greatly increased on account of the uprising, and the wharves, which at normal times were quite sufficient to handle the traffic, were found inadequate for unloading the vessels. A special pier, therefore, had to be constructed before the discharge of cargo could be performed with any regularity.

The Otavi railroad runs from Swakopmund practically parallel to the government railroad of Swakopmund-Windhuk as far as Roessing before it turns to the northwest. The ground rises from

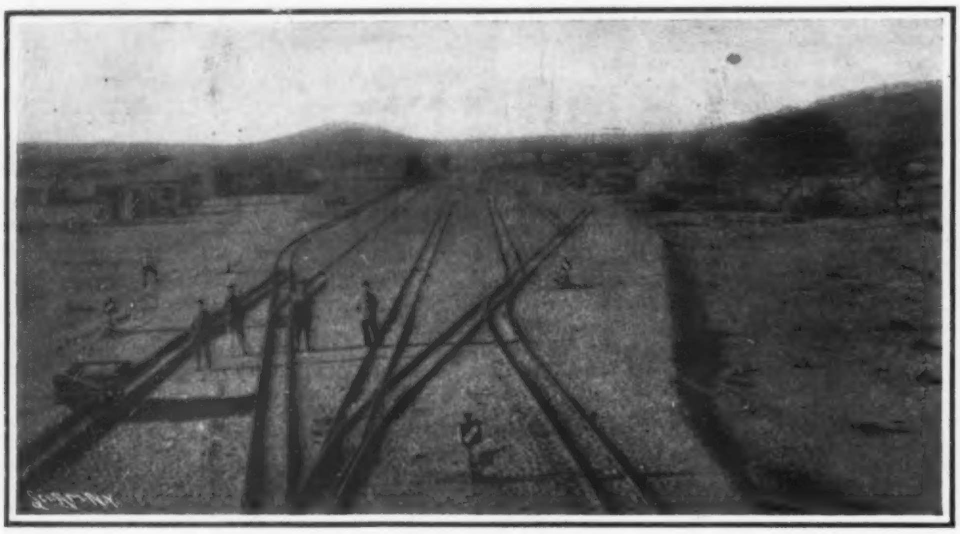


THE EPAKO BRIDGE.

A ROCK CUT IN THE BANKS OF THE OMARURU.

THE SOUTHWEST AFRICAN RAILWAY.

Swakopmund, which is situated 49.2 feet above sea level, to a height of 5,217.9 feet at its highest point. The railway, as far as Omaruru, traverses a desert, passing first through the Namib and then through wide steppes covered with grass and bushes, where scarcely any water is to be found. It may be stated



USAKOS STATION.

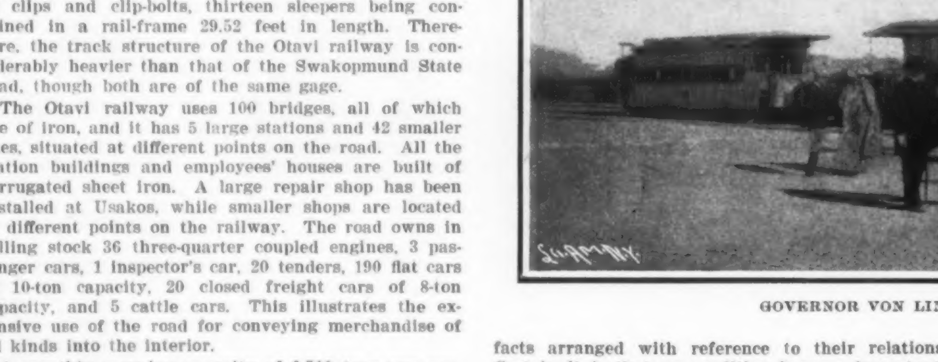
that the borings later made, both by the government and Messrs. Koppel, at such places as had been designated by Herr von Uslar, with the aid of his divining rod, have given very satisfactory results.

The section of the road terminating at Omaruru was completed in September, 1905, after about two years' work, while the section Omaruru-Tsumed, which is about the same length, was completed within a year. The speed in construction in the latter case was largely due to the ample supply of workmen then available and the less difficult country to be crossed.

The track structure of the railway has a weight of 11.05 pounds for every 3.28 feet, it being composed of steel sleepers 4.5 inches in height and 3.3 pounds in weight. The rails are fixed to the sleepers by means of clips and clip-bolts, thirteen sleepers being contained in a rail-frame 29.52 feet in length. Therefore, the track structure of the Otavi railway is considerably heavier than that of the Swakopmund State road, though both are of the same gage.

The Otavi railway uses 100 bridges, all of which are of iron, and it has 5 large stations and 42 smaller ones, situated at different points on the road. All the station buildings and employees' houses are built of corrugated sheet iron. A large repair shop has been installed at Usakos, while smaller shops are located at different points on the railway. The road owns in rolling stock 36 three-quarter coupled engines, 3 passenger cars, 1 inspector's car, 20 tenders, 190 flat cars of 10-ton capacity, 20 closed freight cars of 8-ton capacity, and 5 cattle cars. This illustrates the extensive use of the road for conveying merchandise of all kinds into the interior.

A monthly carrying capacity of 2,500 tons was proposed when the road was under construction, figuring that the Tsumed mines would be in full operation. This estimate, however, has been exceeded, to a great extent, although the operation of the mines has as yet not been started.



SIGNALMAN'S CABIN IN THE NAMIB.

THE SOUTHWEST AFRICAN RAILWAY.

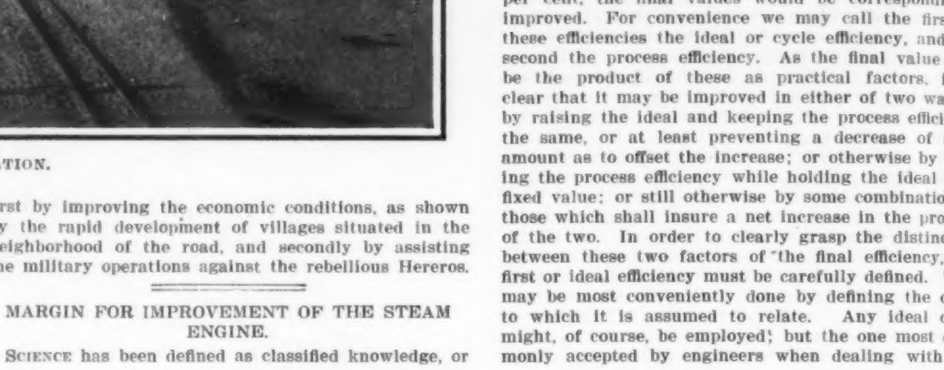
In August 4,000 tons of government and private goods were carried, in September 6,500 tons, and in October 9,600 tons, and in addition to this a monthly average of 2,500 passengers. This capacity speaks excellently for a railway whose gage is only 600 millimeters (23.4 inches).

The trains average between 9 and 16 miles an hour. Although these figures seem very low to us, we must remember that formerly the journey from Swakopmund to Omaruru took two to three weeks, while now it can be accomplished in less than a day.

The railway has been most beneficial to the colony, first by improving the economic conditions, as shown by the rapid development of villages situated in the neighborhood of the road, and secondly by assisting the military operations against the rebellious Hereros.

MARGIN FOR IMPROVEMENT OF THE STEAM ENGINE.

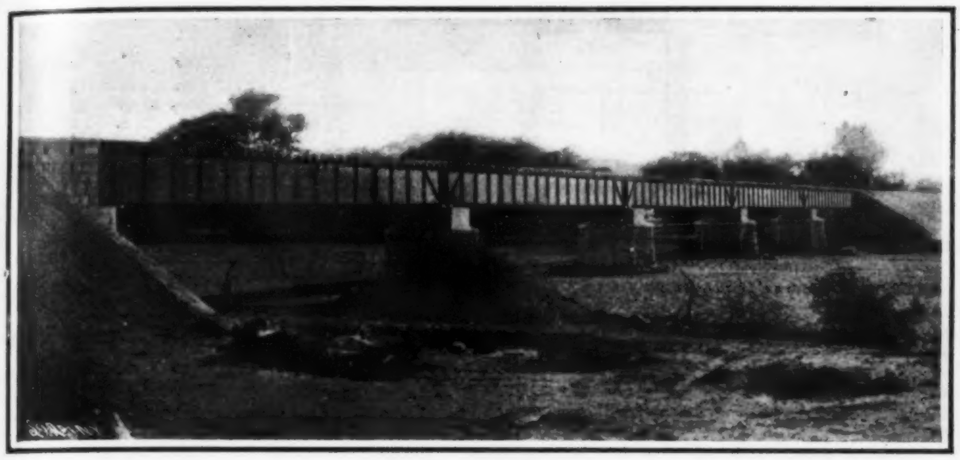
SCIENCE has been defined as classified knowledge, or facts arranged with reference to their relationship. Certain it is that no condition is more important for the study of any problem than the orderly arrangement of all facts bearing upon it, and their reference to such fundamental principles as may serve to bind them into a coherent whole. Nowhere, says the Engineering Record, is this more forcibly illustrated than in the study of the conditions affecting the improvement of the steam engine, or more generally the steam power plant as a whole. During the past hundred years and more the steam engine has been made the subject of numberless modifications and improvements, all looking toward a higher measure of economy. It will be of interest to consider briefly the more important of these various improvements with reference to the cycle of the steam engine, their relations individually to the problem, and the conditions imposed on each by reason of physical conditions beyond our immediate control. The entire cycle of the working substances in the steam engine includes the boiler feed-water heater, and condenser, as well as the steam cylinder, and this entire experience or cycle must be kept in mind in any study of the conditions for improved economy. In considering the cycle of the steam engine it is most convenient to start with some standard or ideal, and then to study the various possibilities of improvement under two heads—first, those which have reference to the improvement or lifting of the ideal; and second, those which have reference to the closer realization of the ideal, whatever it may be. Thus we may have a series of ideal cycles or sets of conditions for which the values of the efficiency may be 18, 20, 22, 24 per cent. It is obviously of importance to understand clearly the steps which shall enable us to improve this ideal from the lower to the higher values. Again, if we succeed in a final realization of only 70 per cent of our ideal, the actual values will be from 12.6 to 16.8 per cent, while if by improvement in the conditions the measure of realization could be lifted to 80 or 90 per cent, the final values would be correspondingly improved. For convenience we may call the first of these efficiencies the ideal or cycle efficiency, and the second the process efficiency. As the final value will be the product of these as practical factors, it is clear that it may be improved in either of two ways—by raising the ideal and keeping the process efficiency the same, or at least preventing a decrease of such amount as to offset the increase; or otherwise by raising the process efficiency while holding the ideal at a fixed value; or still otherwise by some combination of those which shall insure a net increase in the product of the two. In order to clearly grasp the distinction between these two factors of the final efficiency, the first or ideal efficiency must be carefully defined. This may be most conveniently done by defining the cycle to which it is assumed to relate. Any ideal cycle might, of course, be employed; but the one most commonly accepted by engineers when dealing with the



GOVERNOR VON LINDEQUISTE LEAVING OMARURU.

steam engine is the so-called Rankine cycle, which consists of the following items or steps: First, heating of the water in the boiler from the temperature of the condenser to that of boiling, and then vaporization at this temperature to the condition of dry and saturated steam; transfer to the cylinder of the engine without condensation or change of physical condition, and then expansion under adiabatic conditions down to the pressure and temperature of the condenser. Then condensation at fixed temperature and pressure back to the condition of liquid, and transfer to the boiler, thus completing the round. For such a cycle the efficiency may readily be shown to depend on the two limiting temperatures, that of boiling and of condensation, and, in general, to increase as the range between these two is increased. With this understanding it follows that the ideal efficiency is determined solely by the upper and lower temperatures of the cycle, while the degree to which we are able actually to realize these values gives the measure of the process efficiency. From this new point it will then be a simple manner to classify the various items which may enter into the problem of the improvement of steam engine efficiency, and to note the character of their limitations and what degree of improvement may be fairly expected of each. Thus the general advance in steam pressure means a continuous lift in the upper temperature and a corresponding improvement in the ideal efficiency. The limitations to improvement in this direction are found in the fact that as the pressure is increased there is an increasing tendency toward heat loss by radiation, and likewise the need of a constantly increasing ratio of expansion for the steam. If the conditions are not met there will be an increasing loss in the process efficiency, and thus in the end a loss in the one which may offset the gain in the other. Mechanical difficulties enter also, and having in view the various limitations in this direction, it does not seem likely that any very considerable further advances can be made in steam engine efficiency by increase in steam pressure alone. Again, any decrease in the lower temperature, such as a change from non-condensing to condensing, or any improvement in the degree of vacuum, means a dropping of the lower limit of the cycle

and a corresponding opening out of the temperature range, with a resulting increase in the ideal efficiency. The limitations here are chiefly mechanical, and in a general way the engineer can have as low a vacuum as he cares to pay for, or as low as may be indicated by the Kelvin law for economic problems of this character. The recent improvement in vacuum for the operation of the steam turbine shows what may be done in this direction, and a part of the excellent showing made by this form of prime mover is directly traceable to this factor. For the reciprocating engine the influence on the ideal efficiency is no less direct; but, due to the influence of cylinder condensation, the process efficiency is adversely affected, and in this fact is found the chief limitation to the benefit to be derived from the improvement in vacuum, and the consequent dropping of the lower temperature of the cycle. The possibilities of improvement, so far as the ideal efficiency is concerned, are soon exhausted, for the reason that its value depends simply on the upper and lower temperatures, and the possibilities are therefore limited to such changes as may serve either to lift the upper temperature or depress the lower. On the other hand, the influences which may affect the value of the process efficiency are very numerous, and only the more important can be here noted. In fact, any departure from the simple ideal cycle will have its influence, and will operate as a factor to modify the process efficiency. The most important is perhaps cylinder condensation. This violates the conditions of the ideal cycle by substituting for a charge of dry saturated steam at the end of admission a charge of mixed steam and water. The use of superheated steam is chiefly beneficial because it tends to reduce this action, and thus to improve the process efficiency. The use of multi-stage expansion, as in compound and triple-expansion engines, tends also in the same direction, and were it not for this fact there would be no object in splitting the operation of expansion up into a series of stages and carrying out each stage in a separate cylinder. Again, incomplete expansion plays an important part in the reduction of the process efficiency, and any change which permits of greater expansion ratio, and therefore of greater reduction of pressure, under adiabatic expansion alone, is of direct value with reference to the improvement of the process efficiency. Increased expansion ratio in the reciprocating engine, however, tends to increase the loss due to cylinder condensation, and thus the attempt to improve in one direction is in greater or less measure offset by the tendency to loss in another. These remarks are intended to be suggestive rather than comprehensive, and to call to the attention of engineers the value of an orderly study of all phenomena with which they are concerned, with its analysis and classification with reference to some central or organizing principle. Such orderly study will go far to avoid pitfalls, and to show the natural limitation and possibilities of the various items which enter into the problem as a whole.



KHAN BRIDGE.

MAKING UNUSUAL CASTINGS.

By WALTER J. MAY.

FROM time to time requests for castings out of the usual run of cast work crop up, and when it is explained that such work cannot be done at the usual price, the question "Why?" is at once put, and probably would be difficult to answer offhand. If we lay ourselves open to take all work which is offered, and we stock all sorts of stores and patterns, or make any kind or manner of pattern that might be required, then we shall not find any insuperable difficulty in producing what the customer requires, but of course, some of the requirements placed before the metal founder are purely impossible. Thus, for instance, the writer had a somewhat lengthy and more or less acrimonious correspondence with the head of a firm who wanted to turn out brass castings similar to those which were turned up and burnished in the lathe, and apparently that man thought both molders and casters were arrant fools because this could not be done, although the writer explained a method whereby only polishing would be necessary, a wooden wheel fed with fine emery and water being all that was necessary to reduce the face for polishing.

Now, to get smooth castings you must have fine sand, and to get this obtain some Charlton sand, and get it dry. Then sift through a sieve of from 30 to 50 mesh, rubbing the sand down on a slab until it largely passes the sieve, but do not rub it in the sieve. With brass and other soft metals add from a pint to a quart of pea or bean flour to each gallon of sand, and, after mixing, again pass through the sieve to insure that the body of the sand is alike all through. If kept dry this facing sand will keep in good condition for months, the quantity required for each day's work being damped down and rubbed through overnight.

Where iron is concerned an equal proportion of floor sand should be dried and sifted, and the required quantity of ground coal should be prepared by sifting, and after the old and new sands and the coal have been thoroughly mixed, they should be again sifted to insure perfect incorporation, and be damped down and stored away ready for use.

When the molds are made with these facing sands they may either be smoked or lightly dusted with plumbago or ground steatite, sleeking with a soft brush if necessary, or in some cases the patterns can again be pressed in, provided the exact position as originally fixed is maintained. These details, of course, will occur to the expert molder, and need not be extended, the only point being that with fine sands very ample venting is necesssary.

Occasionally very fine castings are made in well-sifted, very fine loam as used by gardeners, but this material is usually too fine and sticky for working in metal unless the utmost care is taken in the selection of the particular sample of loam to be used.

With sand prepared as mentioned above plus well-finished and varnished patterns, and, of course, good molding, castings with perfectly smooth faces can be produced, but necessarily not at the same cost as those which have less time spent on them. Few persons will pay the extra cost, however, and probably only those foundries producing for work in the departments connected with them will go to the trouble and expense of fine castings, although when properly used they pay well.

Besides fine-faced castings, often oddly-shaped spare parts have to be made from broken and damaged specimens sent in, and these often have to be more or less built up. In come cases full patterns will have to be made, in others the molders can make up sufficiently, and in others plaster false backs will be found useful in keeping the pieces right for molding, but each job will require treatment suitable to its own requirements in any case. The difficulty in this kind of work lies in the contraction, and particularly is this felt where the articles are of some length. If too much rapping out is done the pattern or design of the article is spoiled, and if rapping out is not done the new casting is smaller than the one used as a pattern, and often from this cause trouble arises. In jobbing foundries this kind of work is pretty frequently cropping up, but it does not come into the large foundries making specialized work very often, but when it does come it is very often voted an unmitigated nuisance, as the men are not used to it.

The casting of iron or steel pump plungers and the like with brass or gun metal is a rather unusual thing in the majority of foundries, and very often comes out rather badly. The iron should be cleaned and carefully tinned, and the casing should be put on as two castings, one over the other, this producing a sound outer casing as a rule. In general, phosphor bronze is best for these casings, as it usually casts up sounder than brass or gun metal, but these alloys will cast up pretty well if 0.25 per cent of phosphorus is well stirred in just before pouring. The use of phosphorus has disadvantages in the metal as a general rule, but for the purpose mentioned may very well be used.

Screws with both internal and external threads can be cast in any metal if they are needed, and in some cases there is an advantage in casting instead of cutting square threads for some kinds of work where extreme exactitude is not required. Still the work is of an unusual character, and it needs a little practice to get the run of the thing properly, as for internal threads three-part core boxes are wanted, and for external threads considerable care is needed in molding even when split patterns are used. At the same time there is little more trouble than in working spirally ornamented work, always, of course, presuming that well-fitted—and fitting—flasks are used. Malleable cast iron can, of course, be cast in well-made chills so far as external threads are concerned, and after being annnealed can be dressed up with a fine-cut file if any fins are left at the joints. In casting screws due allowances for contraction must always be made, and beyond this there should also be great care taken to have smooth-faced castings, because if rough there will be mechanical difficulties in the way.

Besides mere shapes in castings, the use of some new metal or alloy will have to be taken in hand occasionally, and both molder and melter will often come to grief at first, and for this reason a few trials should be allowed. Even with aluminium there are still both molders and melters who are yet unable to handle this metal well, and this even when it is admissible to use some 2 per cent or 3 per cent of aluminium as a flux. Good type metal often puzzles molders who have not handled it previously, owing to its lack of contraction, while the melter usually overheats this class of metal. In fact, most metals are held too long in the fire, the metal being ready before the molds, and a rule should be made in all cases that the molds shall be ready and waiting for the metal instead of the reverse being the case.

Taken as a whole, unusual working in the making of castings necessitates the employment of men of wide and varied experience, and who are also ready to learn and add to their previous experience, and unfortunately such men are not too plentiful. A molder with good and long experience in a jobbing foundry where iron and other metals are handled by the same men is often of the greatest value in any works foundry, because not only has he experience of a valuable character, but he is also resourceful, and can do things which the specialized man would not attempt.

Unusual castings cannot be made at the same cost per ton for wages as the ordinary work, a point to be borne in mind; but generally what is spent in the foundry is saved in other departments, and the final cost often comes out less than is usually the case with finished work.—The Practical Engineer.

CHRISTMAS TRAIN OF EMPLOYEES CROSSING THE ETIRO BRIDGE.

THE SOUTHWEST AFRICAN RAILWAY.

THE MECHANICAL DESIGN OF BALL BEARINGS AND ROLLER BEARINGS.*

By W. S. Rogers.

The first important thing to know about ball bearings or roller bearings is the material to be chosen. This question can be decided only after one knows where the bearing is to be used, the revolutions per minute, the maximum load, whether the load is constant or intermittent, and the care the bearing will receive in service.

The balls should be of the best quality in all cases. In selecting them the reputation of the ball maker is

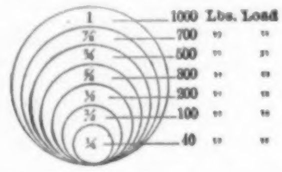


Fig. 1.—GRAPHIC FORMULA FOR DIAMETERS AND LOADS

the only guide, as the largest manufacturer does not always make the best balls, neither is the highest-priced ball always the best. I have found from experience that hot-forged balls are the strongest, provided the maker has used the best grade of steel for the purpose. The honesty of the ball maker must be depended upon for this.

The balls should be accurate. This the user can determine by measuring them for himself. Knowing that perfect accuracy cannot always be obtained, I have always used the formula shown in Fig. 1.

The material for the housings, or shells, sleeves, rings, races, or cones, as they may be called (for the nomenclature of ball or roller bearings has no standard) must be determined by the conditions. Jessop's tool steel may be suitable in one condition, uncalled for in another, and totally unfit for the duty in still other conditions, and the same may be said of every known brand of steel. Practical knowledge of past performances is the only safe guide. Laboratory trials under refined atmosphere prove very, very little.

Assuming, then, that we have the best of materials obtainable for ball bearings, the question is, What is the best form of bearing? But before going into the problem, let us see what the ball has to do in the various types of bearings.

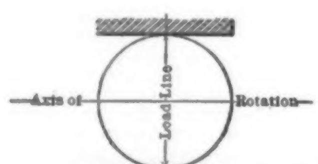


Fig. 2.—RADIAL BEARING.

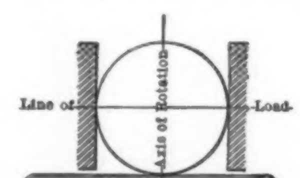


Fig. 3.—THRUST BEARING.

There are but two original purposes of bearings, consequently there are but two original types. One type serves for carrying the load directly upon and at right angles to the shaft or axle. This is termed a "radial" bearing. The other type takes the load of the shaft or axle endwise, or parallel to it, and is termed a "thrust" bearing.

Fig. 2 shows a radial bearing carrying a load upon the shaft. It is plain to see that the axis of rotation of the ball is parallel to the shaft and at right angles to the direction of load and resistance. With proper design and good materials, such a bearing will last a long time and save friction.

Fig. 3 illustrates the simplest form of thrust bearing, in which we note that the axis of rotation of the ball is at a right angle to the shaft and parallel to the direction of load and resistance.

Thus, we see that the natural ball actions in the two fundamental types of ball bearings are in direct conflict with each other, and that it is contrary to the established laws of mechanics for a ball to have more than one axis of rotation at the same time without adding a friction and resistance of its own which eventually destroys itself as is shown in Fig. 4.

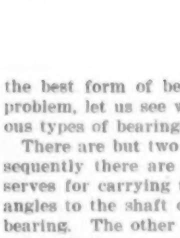


Fig. 6.

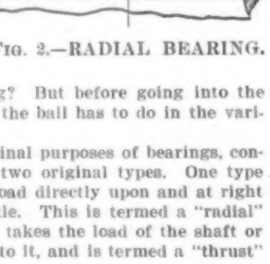


Fig. 7.

Here we have the radial bearing with its rotation of A A used in combination with the thrust bearing having its rotation of axis B B—one ball used to perform two functions diametrically opposed. Simply impossible and absurd on the face of it! The result is that the ball wears out of round, cuts grooves in the contact surfaces, and eventually crumbles away or breaks, ultimately destroying the entire bearing. But this is not bad enough, and we have another invention shown in Fig. 5.

Here we have the opposing plates of load and resistance joined together. Not satisfied with trying to

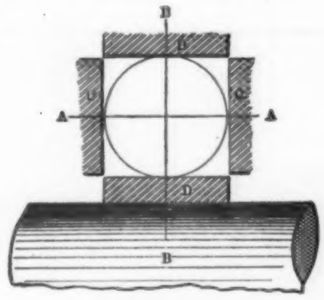


Fig. 4.

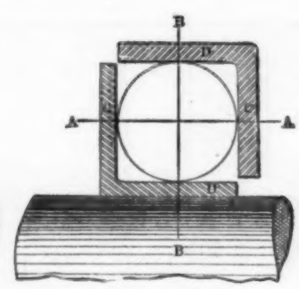


Fig. 5.

make the ball turn two ways at once, the two resisting plates are united to prevent their eliminating the error existing in rolling contact, and compelling the ball to grind itself and the plates away faster. A modification of this type is found in Fig. 6, but still possessing all its evil features.

The good point which this type has to recommend it is that it can be "adjusted" and the wear taken up, but as we only know the time for adjusting has arrived when the bearing has crumbled away, the recommendation in its favor possesses little value.

The next modification of the inventor in his efforts to make a sphere rotate on two axes at the same time is found in Fig. 7.

Here we have the three-point bearing. It is adjustable and the designer has eliminated one rubbing surface and "it spins like a top." But he has forgotten or else does not know that the top has but one axis of rotation and that when he removed one contact surface he left the resistance to be distributed between the other three points.

Then we have another effort in the attempt to make two conflicting laws into one illustrated in Fig. 8. This form is not new; it was developed over twenty years ago, but has become fashionable in the past two years. For use as a bearing to carry a radial load only, this type is all right and will last indefinitely if properly lubricated and cared for; but its advocates are forcing it into use both as a radial and thrust bearing, much to the sorrow and expense of the buyers and users, who assume that the sellers of an article are experienced in all points relating to their business.

Some years ago a form of thrust bearing illustrated by Fig. 9 was brought before the machinery world and great things promised for it, but it quickly proved worthless, although I very much doubt if the mechanical reasons for its failure are yet clear to those most interested.

As the figure shows at once, it was of the four-point contact form, one grooved collar being tight upon the shaft and free from contact with the pulley, the other collar being free from the shaft and tight in the pulley; but it was the same effort to make a ball go in two axial directions at once. This form of bearing is good for thrust purposes only, and at very low speed has been successfully used for many years, its only error being in the angles of contact of 90 degrees.

Forty years ago the forms of ball bearings were

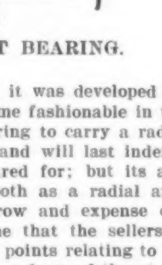


Fig. 8.

developed and used as shown in Figs. 2 and 3. During that period and up to the present time there have been about eleven hundred "patents" taken out by inventors upon the same devices, but disguised by varied curves and angles with meaningless descriptions.

The theoretic and practical radial ball bearing is seen in Fig. 10. The misfortune shown in Fig. 9 resembles it somewhat at first glance, but they are in widely different classes.

In this type of ball bearing the ball touches the raceways and spool at four points, thus forming a square of resistance through its axis of rotation, and the rolling motion of the ball is uniform—equal to that of a roller. This design of bearing eliminates more friction than any other and is the most expensive to make owing to the great accuracy required in grinding the contact angles so they may be true with the bore and the outside diameters as well as true with the sides.

It will carry as much load as a two-point bearing if true and accurate. For this reason the two-point is more popular, as it is much easier to make and at a better profit. This type of bearing can be made adjustable, but should not be used for carrying end-thrust loads.

The most surprising design of a combination radial and thrust bearing ever inflicted upon a bewildered mechanical community is that shown in Fig. 11.

The rollers have round ends, but are sometimes made with a sharp bevel and are held in a cage or retainer. The desire of the rollers under duty is to twist themselves in two, and failing in this they distort the cage and quickly destroy everything. Innocent automobile buyers have suffered greatly from this type owing to its cheapness.

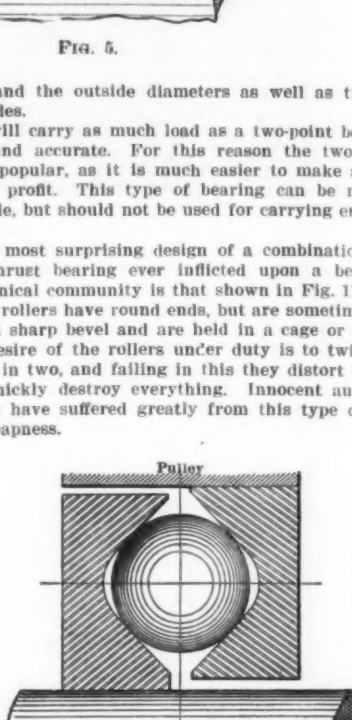


Fig. 9.

Fig. 12 illustrates another form of design of both ball and roller bearings that inventors and promoters have spasmodically tried to introduce for the past thirty years. A small ball or roller is interposed between the large ones carrying the load, with the assumed idea that the smaller ball eliminates the friction of the surfaces of the larger ones produced by their rolling in opposite directions. The fact of the matter is the balls or rollers are never in contact when under load in the design, as shown in Fig. 13. The weak point in the type shown in Fig. 12 is the high speed of the smaller ball or roller which rapidly destroys its usefulness.

Sometimes the question is asked, how much friction is caused by a retainer or cage used to guide and keep the balls or rollers in place, and it can be answered by saying that such friction is infinitesimal and not worth taking into account. The chief thing to consider is the elimination of unnatural friction and work for the balls or rollers.

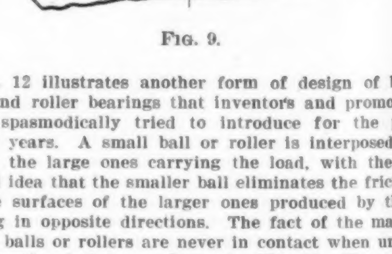


Fig. 10.

Fig. 14 shows another freak in the form of a "ball end-thrust roller bearing." When first exploited it was as a bearing to take the end thrust as well as direct load. The proposition was too ridiculous for the mechanical public, and the "end-thrust" part of it is in the dim past. A is the roller; B B are balls socketed into either the roller or the cage end, C—or both, as fancy pleases. The balls act simply as gudgeons—noth-

* The Engineering Magazine.

ing more. Were the ends of the roller rounded or made to conform to the shape of the ball the same result would be accomplished at much less expense. Nevertheless, it is a good roller bearing.

A form of bearing for carrying the direct radial load and at the same time assuming some of the end thrust is the conical roller type. The circles of rolling contact are not all true and it is not the perfect friction-

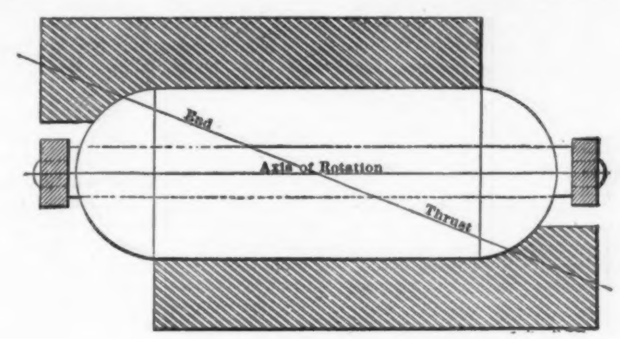


FIG. 11.

less bearing many of its advocates claim; nevertheless it is a happy medium between an easy roll and a wedge, and will endure greater abuse than perhaps any other type or form. There have been many forms of this design shown in Fig. 15. What is the correct pitch or angle of rotation of the rollers with reference to the shaft is unknown, as no comparative trials have ever been made.

A roller bearing with long cylindrical rollers should be avoided always. The frequent inaccuracy in grinding the rollers so as to preserve the same diameters at the ends and in the middle prevents an even, true rolling motion under load. The tendency of one end of a roller to travel faster than the other end starts the cage or retainer to winding or twisting, and the whole fabric becomes worthless. Rollers should never be made more than 4 inches long, and then only when ¾ inch in diameter or larger. Even when no cage is used this tendency of the rollers to ride out of parallel to the shaft is apparent. For this reason there should always be allowance given between the outside shell and inner sleeve of plenty of play for readjustment of the rollers unless they have come to the side of the shaft where they are free from load.

The same reasons exist for making ball bearings "easy fits" or what we might term "shaky" when assembled. The most worthless bearing made is that which is assembled by force.

The thrust bearing shown in Fig. 3 is the most popular because of its ease to make. It is durable as well,

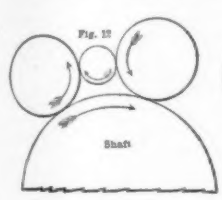


FIG. 12.

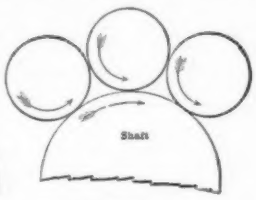


FIG. 13.

notwithstanding the eventual loss of spherical shape of the balls on account of the effort exercised by the two opposing collars to drive the balls on two different rotating axes at the same time. In addition to the motion shown in the illustration the ball is compelled to travel in a circle at right angles to its axis. This causes slight wearing friction. At speeds over 400 revolutions per minute there is also a tendency on the part of the balls to fly outward and cut their way out of the cage or retainer. This they eventually do, and to overcome this the bearing shown in Fig. 16 is used. It is simply a two-point bearing, the balls rolling in grooves. They may be held in a retainer, or not; it is immaterial. The cage is simply for convenience in handling. This type of bearing may also be made with but one grooved collar. When the two grooves are used care must be taken to see that the ball races are concentric with each other and with the inner diameters when they are to be used upon a shaft.

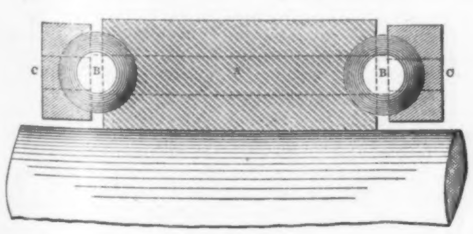


FIG. 14.

Another type of end thrust sometimes called a four-point bearing has been shown in Fig. 9. This is rather an expensive berring unless used at slow speed and for heavy loads.

The correct thrust bearing in point of durability at extremely high speed, and as a load carrier, is seen in Fig. 17. This is the true, rolling four-point thrust bearing—hard to make—but when once made accurately and of good material, it is a "beauty and joy forever." Few are in demand, as the first cost is too great for the weight of the bearing commercially.

Bearings of this form have been taking end-thrust load and running 12,000 revolutions per minute for the past seven years, every day in the year. They are also practically noiseless if the angles are correct. Care must be observed in making them to have the angles of contact a true rolling surface with the cross section of a cone produced by correct included angles from the center of the shaft. These angles must also be concentric with each other, and with the inner diameter of the collars as well. For high rotative speed it is essential that the bearing be as nearly balanced as possible.

Fig. 18 illustrates what engineers would term a "makeshift" thrust roller bearing, suitable only in contracted and narrow spaces where the load is greater than a ball bearing of the same size would sustain.

On can readily see that it is not right; the circular motion of the cage or carrier of the rollers is shown by the arrow *a*. The determination of the rollers is to travel tangent to *a* as shown by the arrow *b*, causing constant slipping and resistance. But it is about 25 per cent better than none whatever, and works quite a long time at slow speed and has been before the public for about thirty years. I am often asked if this type of bearing cannot be made in halves, and my answer is, "No"—because the action of the rollers when passing over the joints of the hardened steel collars is the same as that of heavy car trucks upon railroad track joints—only worse, as the steel collar joints are very brittle and the chips soon cause the rollers to clog and slide.

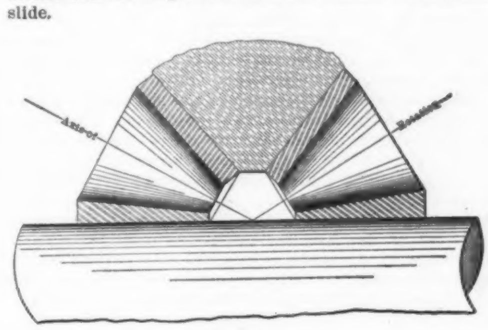


FIG. 15.

The best form of end-thrust roller bearing is that shown in Fig. 19. To be perfect in every way there should be an additional end-thrust bearing on the outer end of each conical roller. This makes a very expensive bearing when completed, but it will withstand great loads at very high rotative speed.

In this article I have said but little concerning the cages, retainers, or carriers for holding the balls or rollers in place, for the reason that their name is legion and after all is said and done there has been nothing new developed or patented in the past twenty years that had not been anticipated by mechanics and inventors in years gone by. Recent court decisions have proven that patents obtained within the past eighteen years are, to all commercial intents, worthless.

I am asked how close a fit should the collars of a thrust bearing be to the shaft, and I say, 0.01 inch, not less.

The man who advocates less knows nothing of expansion or contraction, and is close kin to the crank

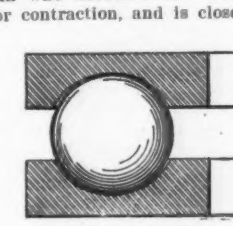


FIG. 16.

that spends hours of valuable time every day trying to part his hair absolutely in the middle.

I am often asked, "How lon will a bearing last?" It all depends upon where it is used, how it is used, its design, and who made it.

The same question and answer applies equally as well to emery wheels, steel rails, and beer. The biggest brewery does not always make the best beer.

Another query oft repeated is; "What patents are there that control the manufacture of thrust bearings?" There are no "controlling" patents of any kind whatever, and it is either rankest idiocy or else blackmail for any one to claim or threaten such things. The original ball thrust bearing with balls held in a cage between two hard, flat surfaces was granted in 1873. The type shown in Fig. 17 was patented first in the seventies and has been duplicated since several times owing to inefficiency of American patent-office methods.

Nearly seventeen hundred patents have been granted since 1833 upon roller and ball bearings. The original one was an application to a grindstone. As I have

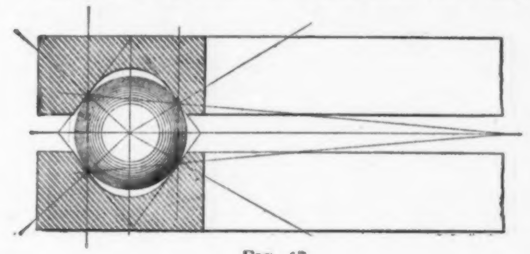


FIG. 17.

stated, the mass of existing patents to-day are not worth the paper they are printed upon except as "promotors' assets." Nevertheless, the industry is but an infant; growing, and yet in its knickerbockers.

GYPSUM (PLASTER OF PARIS) AND ITS UTILIZATION.—I.

AMONG the materials with which nature has so abundantly endowed us, gypsum, notably the gypseous rock, the anhydrite from which it originated, alabaster, holds by no means the least important place, and the immense masses in which this mineral occurs, must have led at an early period to its employment and utilization, while the efforts to make these valuable deposits serviceable to man, have extended the circle of

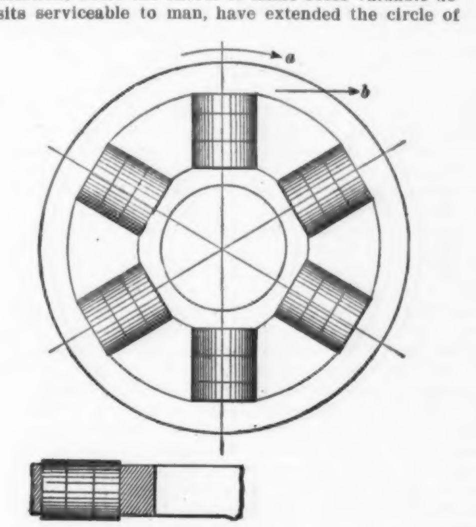


FIG. 18.

its utility until, as a matter of fact, gypsum has become one of the most extensively used substances.

In the very earliest times people were familiar with gypsum or plaster and knew very well how to use it. We hear first of its use through Herodotus, who found the ancient Ethiopians employing it, after it had been burned, for coating the dried bodies of their deceased relatives, creating thereby a solid body, in human form, which, after it had hardened, they painted in colors, and in this condition handed it down to posterity. The Egyptians of old used gypsum for mortar and the great Pyramid of Cheops is built with mortar consisting of 83 per cent of gypsum. In other writings, reference is made to gypsum, or plaster; thus Pliny and Vitruvius refer to its use in building operations as a cement, but more especially to its employment for the stucco work that was so extensively practised in the olden times.

Pliny, moreover, informs us that Sysistrates, of Sykion, being acquainted with the property plaster pos-

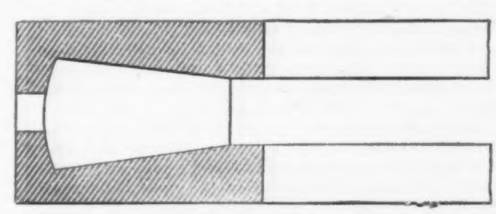


FIG. 19.

sessed of assuming any form given to it and then hardening, made use of it in the production of casts; he was the first to take a cast of a human face in plaster and pour wax into the mold, whereby he obtained a reproduction, perfectly true to nature, that could be utilized for various other purposes. Gypsum powder was used for scattering over the floor by the circus performers in the arena, and later, the transparent, colorless gypsum, or selenite, was adopted by the early

Christians as the symbol of purity and chastity and it was used to decorate the statues of the Virgin Mary, whence the name "Marien glass," or isinglass, applied to the well-known glass-like foliæ of this substance. The use of alabaster for artistic purposes, for sculptural figures and various vessels, is certainly quite as old, and large slabs of selenite were used in the olden times in place of glass, for lighting the interior of dwellings. Later, the art of working in gypsum—we speak of gysum or plaster in its artistic application—was lost, to be taken up again at a much later date in Italy by Margaritone. At the time of Raphael, it is said to have been brought to perfection by the painter Nani and the many fine specimens of stucco work in the Vatican bear testimony to the skill of the individual artists who used it.

In Germany, especially in neighborhoods where gypsum is plentiful, remains of old buildings exist, which the records have proven to have been demolished in the fourteenth and fifteenth centuries; they were built with gypsum mortar and to-day display a solidity unattainable with lime mortar. That plaster casting was practised in Germany in the sixteenth century, is demonstrated by the appearance of a number of different treatises on the subject, in a book published in Nuremberg in 1696; on the other hand, the stucco work here and in France dates only from the eighteenth century, where, especially during the Rococo period, it played a very important part.

In the last (nineteenth) century, the use of plaster has increased very materially. As a building material it has attained considerable importance, being not only used as mortar for flooring, for plastering ceilings, also as a finish for ceilings, for running moldings, etc., but also for the production of artificial building materials, such as plaster blocks, plaster boards, and tiles, etc., while in combinations with a wire network and iron rods it is used for the erection of complete structures, which display considerable durability and have also the important advantage of rapidity of erection, the plaster hardening quickly and drying out just as rapidly. Buildings intended for exhibition purposes are built, nowadays, almost wholly of plaster; plastered with gypsum mortar, all the plastic ornamentation, mostly in bas-relief, is of plaster; in fact, it would doubtless be impossible to erect such buildings in so short a time but for the use of plaster. Here, then, we have one of the chief uses of gypsum, which the low price of the material and its other advantages fully justifies. There are, of course, opponents of the practice, who, without further consideration, urge that plaster is not weatherproof, because the so-called plaster figures are very fragile objects; but apart from the fact that a very thin plaster mixture is used in their production, they are usually hollow, and it is also not impossible that in making them, plaster that has been "killed" in the burning or that has lost its setting properties by transportation or prolonged storage, has been used. Just as ordinary lime paste, if used thick, makes a very unsatisfactory mortar, that remains soft but is rendered useful by the admixture of a proper quantity of sand, so gypsum in proper proportions and used in the right manner, becomes a useful building material. As a matter of fact, it has been so used for centuries in certain localities, where it occurs as gypsum rock and is quarried. The old castle at Osterode, in the Harz, which was demolished in the middle of the fourteenth century, was built entirely with gypsum mortar, and in the still existent ruins the mortar is so hard that it yields reluctantly to the hammer. At Luneburg, Goslar, etc., other structural remains exist that are more than five hundred years old, in which plaster casts, plaster coating, etc., are still completely preserved, although they have been exposed, for all the centuries past, to the elements. "Luneburger lime"—coarsely ground, impure gypsum—is still used extensively, near the place of its origin, for large structures and for hydraulic work. The solidity of gypsum mortar is conditional on its being used as soon as possible after it has been prepared, before it has begun to set. Made in small quantities and used quickly, like cement, it is just as durable as lime and cement. As a matter of course, where, as in some neighborhoods in which gypsum is the most readily available material for building, so much plaster is made up in the trough at the beginning of the working day that it is still being used in the late afternoon, or where, to crown all, what is left over when work stops one day is mixed up the next, with some fresh plaster and a few buckets of water, there is small reason for surprise that such gypsum mortar proves unsatisfactory and is good for neither mason work nor finishing.

Plaster finds a further extensive use in the production of molded objects, an art, which like the making of plaster casts, has come to us from Italy, proof of which is furnished in the predominance of Italians, or people of Italian origin, in the industry. Plaster casting, originally confined to the simplest forms, has developed, in the course of years, into an art, the plaster casts being turned out in a more advanced stage of completion and ornamented in the most diversified manner. Plaster casts in the natural color, i.e., white, are somewhat rare, at least it is usually sought to impart to the cold white color a somewhat warmer tint, yellowish and resembling ivory, if they are not bronzed, made to resemble real bronze, or painted with gay colors, given a polychromatic treatment, which imparts to them, as colors always do to cold, stark objects, a more lifelike appearance. Naturally, the sculptor, the real creative artist, is opposed to this multiplication of gypsum plastics. But we must not forget that comparatively few people are in a position to acquire the original productions of the sculptor, and yet have a taste and liking for their works, which in the form of plaster casts are accessible to them in great variety. As a matter of fact, the sculptor could not do without the plaster cast and the use of gypsum in the exercise of his art. Moreover, the plaster cast has been of the greatest importance to antique sculptural art, which, in excellent reproduction, it has brought within reach of the whole world.

As a fertilizer, gypsum has been long in use. It ranks in this respect with the mineral substances which promote the solution of the nutritive substances in the soil, enhance the effects of mechanical tilling, and by this means exercise a beneficial effect on the increase of soluble nutriment. In a productive soil, mechanical tilling and fertilization stand in a definite relation toward each other—in a certain sense, they complete each the other. Gypsum fertilization has proved itself specially advantageous in the cultivation of clover crops.

By treating wine with gypsum, so-called "plastering," we aim to make it earlier bottle ripe and more fiery in color. It is chiefly in France, Spain, Portugal, and Greece, and more particularly in the case of red wines, that this process is resorted to, and it consists in adding to the wine, usually, however, to the must, and sometimes even to the grapes prior to the pressing process, a certain quantity of burned and ground gypsum. The addition of the gypsum to the must and wine is followed by a chemical transformation in the tartar or argol, whereby tartrate of lime is separated in insoluble form and sulphate of potassium goes into solution. At the same time the phosphates of the must or wine are caused to release phosphoric acid. The latter enhances the intensity of the coloring substance of the wine (particularly of the red varieties); the settlement of the insoluble tartrate of lime causes a mechanical clarification of the wine and thereby makes it earlier ripe for bottling. The addition of gypsum to wine is not injurious, but the increase in sulphate of potassium in the wine, caused by the gypsum, is not to be regarded with equal indifference, as sulphate of potassium is an active laxative. Owing to this, the "plastering" of wines is prohibited in some countries; in others it is permitted under prescription of the maintenance of the minimal amount of sulphate of potassium (2 grammes per liter).

Gypstereotyping is the designation of a process for the production, from movable types, of a solid printing plate of type metal. The printing form to be "cast" is secured in a metal frame, or "chase," the type matter oiled and the space above it filled with plaster paste, struck off even with the upper edge of the frame. The plaster cast sets in a quarter of an hour, and being lifted off the form, constitutes a matrix or mold in which the letters appear depressed, the justification in high relief, and in the plaster mold thus obtained, molten type metal is poured.

In galvanoplastic work, plaster molds, saturated with stearine or wax and coated with graphite, are extensively used, and in the manufacture of rubber stamps, as in stereotyping, an impression is taken from type in plaster and in this the rubber substance is pressed and vulcanized.

With broken bones or otherwise injured limbs a rigid bandage, the so-called plaster bandage, is employed, where it is desired to keep the affected part for a considerable period absolutely motionless; in battlefield surgery, especially, the plaster bandage is of the greatest value. The plaster bandage, the virtue of which is based on the rapidity with which the plaster sets, is applied according to various methods. A roll of gauze, flannel, or other bandage material is thoroughly impregnated with finely-ground plaster, dipped in water, and before the plaster has had time to set, the affected part is enveloped in several thicknesses of it; or burned, ground gypsum is mixed with water in a dish to a paste, which is spread in an even layer on the bandage to be applied to the part under treatment; over this is laid another bandage, to which a layer of plaster paste has also been applied. We can likewise proceed by dipping the bandages of the proper form into a mixture of plaster and water and wrapping several thicknesses about the affected part. Any of these processes results in inclosing the part in a capsule which in a few minutes is hard and rigid. Sometimes it is advisable to supplement the plaster by the introduction of wooden or steel splints, which may be provided with joints. As the bandage, if it does not fit accurately, may easily cause injury by too severe pressure, it is customary, before applying it, to wrap the part in flannel or cotton wadding. If it is necessary that places inclosed in the bandage shall be accessible for inspection and treatment, they are exposed by cutting apertures in the bandage. The bandage is removed by means of special scissors (plaster scissors) or knives (plaster knives).

In the manufacture of paper, gypsum is used as a filling for the pulp, to give it greater body and density, so that the paper appears to be made from good pulp, but is hard and brittle and in spite of the most careful glazing, is never very well adapted for writing. The gypsum is employed in the form in which it is obtained, by wetting it with an excess of water by which it is deprived of its setting properties. The mineral substance is plainly evident in the ash, if the paper is burned, and the notable strength of the ash of burned sheets of paper in the manufacture of which it has been used is due to its presence.

In the production of dry colors, gypsum also finds quite extensive employment, usually in copiously diluted form, either as a base on which the color solutions can be precipitated, or as a means of cheapening and adulterating the colors. That such colors are of little value will be self-evident. The plaster used is either killed by heat or slaked by an excess of water. We find, therefore, this substance, which, in anhydrous form (carstenite), might be used as building material, but with unsatisfactory results, owing to its transformation gradually into the hydrous gypsum, serving useful human purposes as vulpinite (at Vulpino, Northern Italy), or otherwise, artistically colored, as alabaster, transformed into sculptural works, as well as in quite a number of other forms (for instance, in the adulteration of cereal flour) in which it is either employed in a subordinate capacity or its use is not generally acknowledged.—Translated from Marco Pedrotti's "Der Gips und seine Verwendung."

A FUTURE FOR THE ICE-MANUFACTURING INDUSTRY.*

By W. E. PARSONS, M.E.

THERE is usually a very considerable difference between making ice theoretically and conducting an ice-manufacturing business for profit.

It is not my intention, however, to pause here to rehearse the causes of failures and disappointments that may have occurred in the past.

I would rather seek a place beside those who have already discovered the road to success and those who are looking forward to still brighter achievements for the future.

In the first place, an ice-manufacturing business, in order to attain the degree of success, should be managed from its inception by a man who is not only conversant with the management of the ice business in general, but who also understands every detail of the manufacturing process—a man who is capable of choosing the best location—who is capable of planning, at least in outline, the entire lay-out of the plant—who is competent to choose the very best machinery, apparatus, etc.—not only as a whole, but in every detail, so as to secure the best possible results in every feature of the plant, and who knows how to develop a system by which he can keep informed at all times as to whether every individual part of the plant is performing its functions up to the maximum efficiency.

So far there are few such men to be found ready-made. They must be made to order. But men will train for such positions just as soon as it is realized that they will be suitably compensated according to the results which they are able to produce. As in any other business, the man who can deliver his ice to customers at a less cost than any one else, is master of the situation from every point of view.

The business must be studied in detail. The site or location of an ice plant affects various items of expense of conducting the business, such as interest on the investment for ground, taxes, assessments, insurance, etc., cost of water supply, cost of delivering fuel to the plant, and of delivering ice to consumers.

I will, at this time, consider only the use of steam power for operating the ice machines. The steam-producing feature of an ice plant cannot receive too much careful attention. The cost of fuel is generally looked upon as a most important item in the cost of making ice. Advocates and builders of different types of machinery and different systems of ice-making offer, as their most attractive claim, a certain number of tons of ice which they are supposed to make per ton of coal. But how many of these ice-machine manufacturers are willing to guarantee the heat value of the coal, or the efficiency of the boilers and its accessories or the efficiency of the firemen, etc.? Of course, these things can be covered by various assumptions by the ice-machine builders; but that does not help the man who manages an ice plant if he is not able to realize the results which these assumptions call for.

It is better to consider the cost of production of steam as the most important item, and not simply the cost of fuel. Then it becomes a matter of determining the minimum cost of producing a given quantity of steam from and at 212 deg. F., with different kinds and types of boiler-room installations, different kinds and prices of fuel, and different kinds and types of firemen, etc. The cost of production of steam should include every item of expense connected with the boiler-room, such as fuel, disposal of ashes, wages of firemen, coal passers, cleaners, etc., cost of water, interest on investment, depreciation, cost of maintenance, taxes, insurance, etc.

Let the costs of operating the different types and makes of ice machines and apparatus be compared in a similar manner to the boiler plant. Charge to the ice machine not coal, but the heat units it requires from the boiler through the medium of live steam and credit it with the heat units which it is able to return to the boiler through the medium of exhaust or condensed steam; all per ton of refrigeration, under a given set of conditions.

Treat the auxiliaries in a similar manner and make comparisons of the relative cost of different types and the different methods of operation.

A copious supply of good cold water is of the greatest value to an ice plant and should be secured even at great cost.

The minimum cost of producing a ton of refrigeration with different machines and apparatus and under varying sets of conditions should be determined independently of the systems employed for utilizing this refrigeration for converting water into ice.

The cost of preparing water by different systems and processes for freezing should be determined and considered.

We should know the real cost of converting water

* Read before the annual meeting of the American Society of Refrigerating Engineers in December, 1906.

into merchantable ice by different processes, and, in determining the cost per ton, the weight of ice produced should be determined by means of scales and not left to guesswork.

In every case there is more or less of the ice, which has been produced, converted back into water during the process of harvesting. This loss varies with the different systems of ice making and should be taken into account accordingly.

The storage of artificial ice furnishes several subjects of controversy. It seems to be the opinion of some that the storage house can be more cheaply refrigerated by means of ice than by mechanical refrigeration.

This question should not be difficult to settle. There is an open field for invention in the line of improved methods of machinery and appliances that may be used for handling artificial ice cheaply and quickly into and out of storage houses.

The greatest opportunities for improvement are not to be found in the provinces over which the several manufacturers of refrigerating machinery and refrigerating engineers hold special and undisputed sway. They are to be found principally in the production and utilization of steam and in the handling of ice.

Ice plants—where conditions and circumstances will permit—should be established on as large a scale as is compatible with a fairly economical delivery system and they should be operated and managed under the direct supervision of progressive, technically educated engineers, who are specially trained for the purpose.

[Concluded from SUPPLEMENT No. 1624, page 26015.]

THE ETHICS OF TRADE SECRETS.*

By FREDERICK P. FISH.

IN some respects the law of trade secrets does not seem quite complete. There have not been sufficient cases arising under sufficiently varying conditions to enable all aspects of the law to be worked out.

For example, under the decisions of the courts there seems to be practically no limit as to the character of the subject matter which may be treated and protected as trade secrets. They may be of small or large importance; they may or may not involve great novelty or real inventive quality. They may be mere business expedients which have a trade value because of their convenience, or because they record useful information. Unlike a patentable invention, it does not seem necessary that they should be "new" as well as useful.

At first sight it might seem that all that was required was that there should be a secret plan or method or device of any kind to entitle its possessor to the limited protection which the law gives.

I doubt, however, if such is ultimately determined to be the law. When cases arise which require a close analysis of the question, it is probable that the courts will decide that there is something necessary over and above the mere question of secrecy to justify the exercise of the power of the court to prevent the use or disclosure by one who acquired his knowledge in confidence or while under contract.

It is well settled that the alleged secret must be a real secret. I believe, however, that before the courts should intervene to protect an alleged trade secret it should appear that it was not only regarded as secret, but that it was distinctly treated carefully as such and guarded by the possessor of it. It should not be enough that he has had it in mind to call it a trade secret, if he ever needed to invoke the protection of the law. He must have taken all necessary and reasonable precautions to prevent its disclosure. Moreover, it does not seem proper that he should have redress against his employees and associates unless it is made to appear that they knew, while occupying the fiduciary relation which gave them the opportunity to learn the secret, that the specific thing now called a secret was in fact regarded and treated as a secret. It should not be enough that one man has worked for another. The employee has a perfect right to grow with his experience. He has a right to carry away for general use everything that he learns in his place or employment, except trade secrets. The public interest requires this as much as it requires that trade secrets should be respected. The employee or associate should be notified of the exact trade secret, that he may know what results of his experience he can and what he can not take away and use freely.

With these qualifications, some of which are perhaps not fully elaborated in the opinions of the judges, there seems no reason to doubt that the law is thoroughly consistent with sound ethical principles. I can conceive of only few directions in which a change of any moment is possible. One would be to the effect that the possessor of a trade secret should publish it to the world so that all might have the advantage of it. Such a law would be incapable of enforcement, for the man who has a thought or an idea cannot be forced to express it. Surely, this would result in no benefit to the community. Again, the law might be modified so as to remove the present restrictions against the disclosure of a trade secret by one who thereby is guilty of a breach of trust or of contract. So long as we maintain our present standards of right and wrong, so long as we value and insist upon loyalty and good faith, would not such a change in the law seem to us inconsistent with all that is good in human nature and the application of a principle which is most distinctly immoral?

Believing as I do that the law of trade secrets is fundamentally right and in accord with sound ethical and social principles, at least as gaged by our present standards, I have not turned aside to consider the possible objections to the views that have prevailed. It seems to me that those objections are largely upon a consideration of the obvious hardships involved in the situation. It is a burden that one who knows a useful thing should not have full power to utilize it. Is not this true of every legal restriction upon the individual?

It must not be forgotten that no man need place himself under the embarrassment of knowing a trade secret unless he chooses. Each of us is free to refuse the employment or the relationship or the contract from which such knowledge would come. If we do not refuse, we must as in all other relations in life, accept the situation as a whole, with its burdens as well as its advantages. There is nothing special, as to trade secrets, in this regard.

Neither must it be forgotten that the right to protection in the use of a trade secret is a general right. It is sometimes suggested that while the rules of law, as I have defined them, were adapted to a former condition of things, they are not in harmony with our present industrial situation. I do not think that such is the case.

It is true that in the early years of the last century, when the trade secret of to-day, in its legal relations, was formulated by the courts as a logical development of the general principles of law, the units of trade were small. Trade secrets were then in the possession of small manufacturers, for there were no large ones. In so far as trade secrets play any part in our industries of to-day, they are necessarily, to a large extent, features of our modern corporation and factory system. I do not see how these changes in industrial conditions affect the question under discussion. The reasons which led to the original protection of such secrets against breach of contract or breach of faith one hundred years ago, are sound to-day.

The law on the subject is the same whether the secret is of large or small importance, whether it is possessed by any individual or a corporation. We should not forget that any one of us in this room, and any workman in any factory in the land, may light upon such a secret. If he does, it will have the protection of the law.

A consideration of possibly more moment is that there is offered to the originator of certain special forms of industrial secrets, or to his assignee, the protection afforded by the grant of letters-patent. It may be contended that the opportunity to patent an invention is all the encouragement to the promotion of the useful arts that is required in the public interest, and that there should be no other reward for the origination of a new thought or of a new method or device than that given by a patent. Passing for a moment the point that only a small class of useful ideas are capable of receiving the benefit of letters-patent and referring only to things that are patentable, such a view does not seem to me fair or reasonable. Why should a man be forced, against his will, to publish what is in his mind?

The whole law of patents implies the right of a man to keep as a secret that industrial improvement which he has conceived. It is because that right is recognized that patent laws exist. They say in effect: "You, the inventor, have a trade secret which is, among other things, new, useful and the result of invention. You may keep this secret if you can, and so long as it is kept secret you and those claiming under you alone may use it. If your secret is discovered without breach of faith, as may be the case at any moment, you lose it absolutely. Do you not prefer to make a contract under the patent law by the terms of which you are to publish your invention in the best form known to you, and in consideration of that publication secure a right, which you cannot otherwise have, and which shall be enforceable by law, to prevent the use of your new idea by any others without your consent for a limited term, say seventeen years?" You will, to be sure, sacrifice the chance you now have of keeping your invention for an indefinite time a secret and, therefore, in your own control, but in return you get the right to invoke the aid of the law to restrain any use without your consent for a certain period. Which course do you think most for your advantage?

As I understand the decisions, even unfairness or want of faith on the part of one who receives knowledge of the secret in confidence, does not make it impossible for him, before he is enjoined by the courts, to disseminate the information so that those who get it from him may use it freely. A person who has notice of the incapacity of his informant to violate confidence, or one who has given no consideration for the information, would be subject to injunction. On the other hand, a *bona fide* purchaser of the secret who had no notice of any breach of confidence or of contract on the part of the one who sold him the information for value, could, I believe, use the information without interference from the courts. He, as a *bona fide* purchaser for value and without notice would have an equity equal to that of the possessor of the secret. Under such circumstances the courts are not likely to interfere.

If a disclosure was wrongfully made in trade journals or otherwise, it would be a difficult, almost an impossible, task for the one whose rights had been violated to secure redress against the entire public who had read of the secret and who were actually innocent of any breach of faith. Moreover, where there is a trade secret, the fact that it exists is likely to be known throughout the trade, and each competitor has the full right to find the secret for himself, using all information as to its nature and the results from it that he can get from an inspection of the product, from speculation, or in any fair way. I will say nothing as to unfair ways that might be employed and which might be carried out with effect, but so shrewdly as to evade the law. No man would prefer a trade secret to a patent if the only question was one between the chance of keeping his device or method to himself indefinitely without publication, and publication with a reasonable certainty of protection during a limited term. But the issue does not come up in this simple fashion.

In the first place, many trade secrets are not of a patentable character. Many such should surely be capable of protection in some way. There is no other possible way than through the present rules of law to which I have referred.

There are many valid reasons why the discoverer of a new industrial process may well determine not merely that it is for his interest to take his chances of keeping it secret rather than to publish it in a patent, but that the latter course might lead to disaster. While it is generally, but not always, easy to prove an act of infringement of a patent, on a product or a tool or a machine, it is often practically impossible to obtain legal proof of the process employed by one who is believed to infringe a process patent. The infringer is very apt to be able to keep his infringement an undiscoverable secret. I am inclined to the belief that a substantial part of the important and valuable trade secrets now in use, would, if patented, be used without much, if any, chances of redress on the part of the patent owner. At any rate, if the one who controls the secret fears that he could not prove infringement of a patent, is it contrary to public policy that he should be allowed to take his chances of keeping what he has discovered a trade secret rather than run the risk of losing it altogether by publishing it?

Again, nothing can be patented unless it involves invention. Pages have been written by way of defining invention. Many of our greatest judges have given all possible thought to the subject. It is still indefinite, however.

Inasmuch as a trade secret is a man's own, to use or not as he pleases, can it be required that he should absolutely give up his opportunity to utilize his idea for his own benefit, and incidentally for the benefit of the public, in his own factory and under the seal of secrecy, and take a patent which might be declared invalid for want of invention, no matter how useful and meritorious the subject matter might be?

It is to me somewhat significant that the legislatures of England and America, which have many times dealt with the patent law, have never directly touched the subject of trade secrets. They seem to have recognized the fairness and justice of the common law rules on the subject, and that the only course which would commend itself to a sound public sentiment was to make the patent laws so attractive as to induce the owners of patentable trade secrets to publish them in consideration of the patent grant. In this way they have to a large extent succeeded. There are an innumerable number of patents, and a comparatively small number of trade secrets. It is only in a few special classes of subject matter that the patent is not a more attractive reward for the new contribution to industrial progress than is the limited protection given by the law to a trade secret. It is only with processes which are practised in a factory and which are not disclosed by a study of the product that there is any substantial chance of maintaining secrecy.

If a man elects in those few cases not to publish but to take his chances, can there be any real objection to his pursuing that course? It is certainly inconvenient and annoying to some extent. It is a real personal hardship that a workman or engineer who has learned the secret under such conditions that he must respect it, cannot utilize it in his subsequent work. It undoubtedly holds back the progress of the useful arts to some extent that the whole world is not free to practise it and to improve upon it. But this, in theory, is equally true as to things that are patented, during the long term of seventeen years in which no improvement on the thing patented can be rightfully used except by the patentee or those claiming under him.

On the other hand, I believe that sound business generally and the comparatively few arts in which such secrets are of any importance are definitely promoted by the fact that the law aids in preventing disclosures based upon bad faith.

Such are my views as to the ethics of trade secrets. They are those of the courts, and I believe of the public. I recognize that all industrial questions are now under investigation. Much good will come from a fresh study of them in their relations to modern social, political, and economic conditions.

The question we have been considering is only one of many as to which the community has had settled views which were reflected in the unanimous findings of the courts. As to some of those questions, it may be that we are on the verge of marked changes of thought which may result in equally great modifications of what have seemed to be sound and permanent industrial and business principles, and in the applications of those principles. The engineers of the United States will surely be on the right side of the discussions of these subjects, and of any political or judicial action which follows those discussions. It may be well in every case to consider the grounds for the doctrine that has prevailed before condemning it altogether. It will always be necessary to determine whether the criticism should not be directed to the applications of the doctrine, that is, to the special cases, rather than to the doctrine itself. In the matter

* From an address delivered before the American Society of Mechanical Engineers at New York.

of the trade secret, there may be hardship or even wrong in special cases. If so, let us find out how to deal with the subject so as to retain what is right and to eliminate what is wrong.

The important thing for us to determine is whether or not the prevailing views as exemplified in the decisions of the courts, are not fundamentally sound, based as they purport to be on principles of thought and action that are in harmony with elementary rules of public policy and good morals. If they are right they should be sustained. For myself, and speaking generally, I cannot see what fairer or more reasonable views could be advanced in their stead.

THE MOTOR TORPEDO BOAT—A NEW TYPE.*

The purchase by the British Admiralty of the motor-driven torpedo boat, recently built and successfully tested by Messrs. Yarrow, must be regarded as an official indorsement of a new type of fighting craft. The vessel was built entirely on the responsibility of Messrs. Yarrow, and under the conviction that there would be a wide field of usefulness in store for it, as forming part of the naval defenses of estuaries and harbors. The original idea of the torpedo-boat flotillas was that they should consist of a large number of small and comparatively cheap units, each possessing high speed, and exposing only a small area to gun fire. In recent years, however, in the endeavor to secure higher speeds, there has been a steady departure from at least two of these essential principles. The boats have grown larger and more costly, until, from the original size of 75 feet, they have grown to an overall length of 150, with a proportionate increase in the cost. The builders of this craft believe that it will be possible, by making use of internal-combustion engines, to return to first principles in these two respects, without sacrificing too much of the present high speed.

We present two illustrations of the type boat, one showing her at her moorings, and the other taken when she was being driven at 24 knots an hour. It will be seen that she is of the general motor-boat type, but that the turtle back extends much farther astern than is customary in the racing craft, and that she possesses a somewhat higher freeboard. Her general dimensions are: length, 60 feet; beam, 9 feet; and displacement, 8 tons. She has three engines driving three propellers, and when carrying a load of three tons, which is considered to be an ample allowance for the weight of torpedoes and fuel, she easily maintains a speed of 24 knots an hour. This may be justly considered as her sustained sea speed under normal conditions of wind and weather. That the great economy of weights in proportion to power is due to the use of internal-combustion engines, is shown by a comparison of this motor-driven torpedo boat with one driven by steam and carrying the same load of three tons. The motor-driven type, with a speed of 24 knots, would have a radius of action for one ton of fuel of 300 miles; whereas the steam-driven type would be capable of attaining only 18 knots an hour, and its radius of action would be but 60 miles. A valuable feature in the craft is that the gasoline is carried in a special tank, which does not form any part of the structure of the hull; so that in case of damage, none of the oil could find its way into the interior of the boat. The armament will consist either of one torpedo carried astern, in a revolving tube, or of two torpedoes mounted in dropping gear, one on each beam. Furthermore, on account of the smaller amount of fuel which it requires, this vessel can carry one ton weight of armament more than a steam-driven boat of the same size.

Since her purchase by the Admiralty, the boat has been subjected to various tests to determine her exact value for defensive purposes. A valuable feature is that a vessel of this size and weight can readily be loaded onto a car, and rapidly carried from one coast to another to meet the emergencies of war. It is suggested that the method of carrying out a system of defense with these vessels will be to provide, in the proximity of the rivers or harbors to be defended, special stations equipped with all the necessary plant for repairs, storage of fuel, etc. The small size of these boats also would enable them to form part of the boat equipment of battleships and cruisers. The earlier attempts to carry torpedo boats on warships failed, because the restrictions on size rendered it impossible to install steam engines of sufficient power to give these boats the high speed which is indispensable for effective torpedo-boat work.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

A torpedo boat of this size driven by steam would have a speed of only 18 knots and a radius of action of only 60 miles.

YARROW MOTOR TORPEDO-BOAT RUNNING AT 24 KNOTS SPEED.

Length, 60 feet. **Beam,** 9 feet. **Displacement,** 8 tons. **Radius of Action,** 300 miles. **Speed,** 24 knots.

THE YARROW MOTOR TORPEDO-BOAT—A NEW TYPE IN THE BRITISH NAVY.

THE MOTOR TORPEDO-BOAT—A NEW TYPE.

WHAT A KILOWATT-HOUR OF ELECTRICITY WILL DO.

The electrical engineer of the municipal lighting plant of Loughborough, England, has recently published a little list showing the inhabitants what a kilowatt-hour of electricity will do for them. It is a good way of selling electricity and of bringing home to the public mind the versatility and wide range of application of electrical energy. Our readers can develop such an idea or table for themselves. Some of the performances are a little vague, but the list as a whole is quite striking and ingenious:

Saw 300 feet of timber (deal).
Clean 5,000 knives.
Keep your feet warm for five hours.
Clean 75 pairs of boots.
Clip 5 horses.
Warm your curling tongs every day in the year for 3 minutes and twice on Sundays.
Warm your shaving water every morning for a month.
Give you 1,250 impressions on a Bremner royal printing machine.
Run a mechanical sieve for 2 hours.
Run an electric clock for 10 years.
Iron 30 silk hats.
Light 3,000 cigars.
Knead 8 sacks of flour into dough.
Fill and cork 250 dozen pint bottles.
Supply all the air required by an ordinary church organ for one service.
Pump 100 gallons of water, or other liquid, to a height of 25 feet.
Run a plate-polishing machine for 21 hours.
Run an electric piano for 10 hours.
Lift $3\frac{1}{2}$ tons 75 feet in 4 minutes.
Give you 3 Turkish light baths.
Keep 4 domestic irons in use for an hour.
Keep you warm in bed for 32 hours.
Warm all the beds in the house, by a warming pan, for a fortnight.
Give you a fire in your bedroom for an hour while you are dressing or undressing.
Boil 9 kettles, each holding 2 pints of water.
Cook 15 chops in 15 minutes.
Run a small ventilating fan for 21 hours.
Run a large ventilating fan for 6 hours.
Keep your breakfast warm for five hours.
Run a sewing machine for 21 hours.
Carry your dinner upstairs every day for a week.
Carry you 30 times from the bottom of the house to the top, 80 feet each journey.
Keep your coffee pot warm at the breakfast table every day for a week.
Carry you 3 miles in an electric brougham.—Electric World.

The cost of improved superheaters with straight tubes and accessibility for repairs should be considerably less than the cost for compounding, and when the cost of fuel, forcing of boilers, or water conditions, warrants the use of an especial appliance for economy.

superheating will be a desirable adoption. As the apparatus can be applied to old locomotives at about the same expense as to new ones, there is an abundant opportunity for its introduction on a large number of locomotives at a comparatively small cost for the increased efficiency.

THE FLIGHTS OF ZEPPELIN'S AIRSHIP ON OCTOBER 9 AND 10, 1906.

From a Report by Prof. Hergesell and Capt. Von Kehler.

Although the construction of the Zeppelin airship is well known it will be useful to indicate the differences between No. 3 and its predecessors.

No change was made in the aluminium frame, which still consists of sixteen cells, each containing a hydrogen balloon, and is perfectly rigid under all circumstances. The 85-horse-power Daimler-Cannstatt motors rigidly connected with the propellers by steel shafts, made about 820 revolutions per minute. The stability was improved by attaching to the stern "caudal fins," or fixed aeroplanes, whose size and position had been deduced from preliminary experiments by Prof. Hergesell with a model which was subjected to an air current of 12 meters (40 feet) per second. It is an important advantage of the rigid frame that these fins can be securely attached at any point. These fins made it possible to reduce the size of the horizontal rudder which had formerly served also as an organ of stability. This consists now of only two surfaces, one over the other, which could be placed close under the hull and thus protected from injury in landing. The propellers were tested on the Count's air-propeller boat. The hubs to which the blades are fastened are from the Krupp works, which alone could furnish hubs of the required strength.

The total cubic capacity of the airship is 11,430 cubic meters (403,500 cubic feet). With five men in the forward and four in the after gondola, it can carry 2,500 kilogrammes (5,500 pounds) of ballast.

FIRST FLIGHT, OCTOBER 9, 1906.

The inflation of the balloons with hydrogen occupied five hours, and was completed at 2:30 P. M. on October 8. At 10:30 A. M. on the 9th, the load was so adjusted as to give each gondola a buoyancy of 60 kilogrammes (132 pounds). At 11:30 the float bearing the airship was towed by a tugboat to the center of the lake, and at 1 P. M. the ascent was made without difficulty by casting loose the wires that bound the airship to the float, starting the forward motor and throwing out ballast. Driven by the forward propellers alone, the ship laid its course toward Constance. From the motor boat which followed, it was seen to obey the helm perfectly and hold to its course very well, except for occasional deviations due to the inexperience of the steersman. Half an hour after starting, the airship made a turn of 180 degrees and then proceeded down the Swiss and up the Wurtemberg shore to Manzell, its starting point. Here the motors were stopped and the airship slowly descended until both gondolas rested on the water, where, after swaying three times from side to side, it came to rest. Supported by the gondolas, it was towed like an ordinary barge by the motor boat to a buoy in front of its shed, where it was drawn up on the float, which was then pushed into its house.

Over this house, on a platform 35 meters (116 feet) above the lake, Prof. Hergesell had fitted up an observatory for the determination of the direction and speed of the wind by means of a captive balloon and small pilot balloons which were observed with a theodilite, which also served for viewing the airship in flight. As the length of the airship was known, it was frequently possible to determine the speed with which it was traveling by observing the time which it occupied in passing over the cross wires of the theodolite. The speeds thus observed during the first day's flight were from 8 to 9 meters (26 to 30 feet) per second when only one motor was used, and from 12 to 13 meters (39 to 43 feet) per second when both motors were in action. On this day the wind was very light, its velocity being about 2 meters (6½ feet) per second, and at times it died away altogether.

SECOND FLIGHT, OCTOBER 10, 1906.

A second flight was made on the following day. The morning was consumed in refilling the partially collapsed balloons. At 1 P. M. the float bearing the airship was towed out by the motor boat, as it was not thought necessary to hire a tug. The result was that, in making a turn, the wind caught the airship on the broadside and drove it back toward the house, dragging the motor boat after it. To avoid collision with the house the float was made fast to a buoy, but at this instant one of the wire cables that bound the airship to the float gave way. Count Zeppelin instantly gave the order to let go everything and by quickly throwing out ballast the airship was enabled to rise over the house, from which it was distant some 200 feet on leaving the water. It was driven several hundred yards inland, but under both motors and their propellers was quickly brought back to the lake at a speed of 14 meters (46 feet) per second. The circuit of the lake was made, nearly as on the preceding day, but as the wind was high the descent was made well out in the lake with no mishap except a slight injury to the stern rudder. The airship was towed inshore by a passing steamer and housed in the manner already described.

In this flight a distance of 110 kilometers (68.34 miles) was traversed in 2 hours and 17 minutes. The proper motion was computed, both from observations with the theodolite on land and observations of places and times made on board, to be from 14 to 15 meters (46 to 49 feet) per second, or about 50 kilometers (32 miles) per hour. At times an actual speed of 22 meters (72 feet) per second was observed, which showed that at those times the airship was moving down a local wind of at least 7 or 8 meters (23 to 26 feet) per second. Much stronger gusts were encountered, for occasionally the ship was brought almost to rest by a head wind, the velocity of which must therefore have been nearly equal to the ship's proper motion. Through these air currents, varying in force and direction, the ship maintained its equilibrium. The very slight tendency to pitch was easily controlled by the horizontal rudder and there was absolutely no lateral oscillation.

In general, the airship floated at a height of 350 meters (1,150 feet) above the water. Its greatest elevation was 450 meters (1,475 feet) above the surface of the lake of Constance, or 850 meters (2,790 feet) above sea level. The smallest elevation was 1,200 meters (650 feet) above the lake. The ballast discharged during the trip amounted to only 180 kilogrammes (400 pounds), including the benzine consumed—0.23 kilogramme (½ pound) per horse-power hour.

Because of the great carrying capacity, the adjustment of the ballast is not a delicate matter, as appears from the fact that, although a workman who had failed to leave the after gondola at the right moment was carried off by inadvertence, the horizontality of the ship was not perceptibly impaired. On the trip, therefore, eleven men were carried, four in the after gondola, and seven—including Count Zeppelin, Engineer Dürr, and Capt. Von Kehler—in the forward gondola.

The abundant provision of ballast and the faultless performance of both motors would have made it possible to prolong the flight to several times its actual duration, but it was deemed advisable to descend in time to house the airship before dark.

RESULTS OF THE FLIGHTS ON OCTOBER 9 AND 10, 1906.

I. Stability.—The great airship, 128 meters (420 feet) long and 11.7 meters (38 feet) in diameter, is with its present equipment of fixed and movable rudders perfectly stable, not only in still air, but in high and variable winds with perceptible vertical currents. The oscillation of the axis observed in a previous ascent had completely disappeared.

II. Elevation.—The elevation was remarkably uniform, owing probably to the rapid flight through the air and the continual renewal of the layer of air which surrounds the gas bags, in consequence of which the gas experiences little or no change in temperature. The absolute elevation could be greatly increased without difficulty, as a very large quantity of ballast was carried.

III. Speed.—In the second flight the mean proper velocity, relative to the air, with both motors working at full power, was 14 or 15 meters (46 to 49 feet) per second. This speed exceeds Lebaudy's record by 3 or 4 meters (10 to 13 feet) per second and surpasses the speed of any ocean cruiser.

IV. Dirigibility.—The airship can be steered with ease and certainty. It made comparatively sharp turns and curves of short radius. For long straight stretches greater experience on the part of the steersman will be required, but in this respect the second flight was distinctly better than the first.

V. Ascent and Descent.—These flights have proved that ascent from and descent to a water surface is quite free from danger with airships of this type.

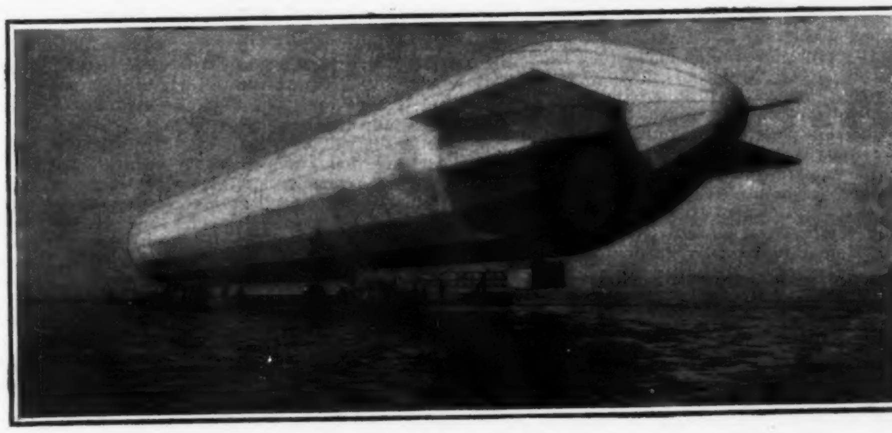
Lack of means compelled Count Zeppelin to abandon his old and approved device of a floating house which automatically sets itself parallel to the wind, and to erect a fixed house into which the airship is brought on a float. This arrangement is provisional and can be used only in comparatively calm weather, for the airship would be in danger of being wrecked on issuing from the house by a violent side wind. A house that can be turned in any direction is absolutely necessary and it would probably make the operation of housing safe even on land, but only after experience and practice had been gained with a floating house.

VI. Duration of Flight.—The comparatively brief duration of these flights was due solely to the time consumed in getting the airship out of and into its house. The amount of ballast, 2,500 kilogrammes (5,500 pounds), and the excellent performance of the motors would have made far longer flights possible.

In conclusion, it should be pointed out that Count Zeppelin now stands at the head of all constructors of dirigible airships. His airship has surpassed all others in length of flight, as well as in speed. Lebaudy's record is 100 kilometers (62.14 miles) in 3 hours and 23 minutes; Zeppelin's is 110 kilometers (68.35 miles) in 2 hours and 17 minutes.—Translated for the Scientific American Supplement from the Illustrirte Aeronautische Mitteilungen.

COMING OUT OF ITS SHED.

This Airship, which is 38 feet in diameter by 420 feet in length and which has a capacity of 367,120 cubic feet, held itself stationary against a 33¼-mile-an-hour wind on January 17 last, by means of two 35-horse-power gasoline motors driving four propellers.



READY FOR A FLIGHT.

The Airship can lift three tons additional to its own weight, which gives it a radius of 3,000 miles at 31 miles an hour.

COUNT VON ZEPPELIN'S AIRSHIP—THE LARGEST AND FASTEST THUS FAR CONSTRUCTED.

It is beyond doubt that alcohol is formed in the fermentation of the dough, although its greater proportion is volatilized during the baking process. (For this reason the dough fermentation was long considered as non-alcoholic.) Belas has formerly proven the existence of alcohol in bread; he found quantities varying from 0.2 to 0.4 per cent. The amounts found by Pohl are considerably lower, varying from 0.05 to 0.08 per cent. The raw distillate was redistilled and the alcohol obtained by rectification was characterized by its boiling point as well as by its convertibility into ethyl iodide.—Pohl-Zeitschrift fuer angewandte Chemie.

GASOLINE, KEROSENE, OR ALCOHOL FOR MARINE EXPLOSIVE ENGINES.

By A. E. POTTER.

THE gasoline engine for marine use has been proven an unqualified success, evidenced by the many thousands employed for the propulsion of all kinds of craft.

Marine kerosene engines have also been manufactured for several years, but at present in this country there is but a single manufacturer offering engines of the marine type on anything like a commercial basis.

Hundreds of thousands of dollars have been spent and squandered in attempts to perfect the kerosene engine, so it could be adapted to marine and automobile use. Vast amounts have also been wasted in trying to bring out an engine for stationary use, in which electrical ignition could be employed, and in all these cases failures have followed failures.

One manufacturing concern after repeated attempts at generating electricity by a dynamo driven by a kerosene engine, the purpose being to use the electricity to operate a commercial vehicle, after several years of discouragement, has closed its plant. Another is said to have spent over $50,000 alone in patents, the ultimate object being to develop a stationary kerosene engine that would run satisfactorily on 150 deg. fire test oil, using electrical ignition. This firm has only progressed sufficiently far to be able to make a fairly good showing, as long as low fire test oil—110 deg. or lower—is used for fuel.

One prominent New York capitalist is reputed to have spent half a million dollars or more in marine kerosene engine experiments. His first attempts were along the well-known lines of the Hornsby-Akroyd type, using the hot ball method of ignition, and four-stroke cycle construction. Whether or not patent entanglements forced a change of plans, is hard to say, but it is quite significant that no one else in this country has attempted to manufacture a similar type of four-stroke engine, using the hot ball method of ignition. Later experiments have been with electrical ignition. With this form of ignition it was found that 5 gallons of kerosene added to a barrel of gasoline gave very much better results, and it is broadly hinted that this proportion has been maintained, even without the knowledge of the party who is backing the enterprise.

These are but three instances where large sums of money have figured, with at best but partial success. The number of experimenters and inventors who have given serious attention to the problem of the kerosene engine is being constantly increased, with, to my mind, but slight chances of success.

It is a mistaken idea to think that the some three thousand fishing vessels in the North Sea, equipped with kerosene engines, employ the grade used generally here for illuminating purposes. Kerosene of 110 deg. fire test is regularly exported, and while more volatile and better adapted for use for power purposes, this may not be employed here for illumination, its use being restricted in nearly all the States by legislative enactment to oil of not less than 150 deg. fire test.

A still lower grade than 110 deg. is said to be used abroad, as well as here, for certain purposes. This is sometimes called "commercial" kerosene. This, on account of its greater volatility, is even better adapted to use in the kerosene engine than the 110 deg. oil.

These products are all composed of different proportions of hydrogen and carbon and are obtained from the destructive distillation of petroleum. The crude oil is heated in a still to a certain prearranged temperature, when the more volatile parts are driven off and condensed. This product is known as crude naphtha, which, in this state, has few uses. Later the crude naphtha is redistilled, purified by means of steam, sulphuric acid or other chemicals, and as the most volatile parts pass over they were formerly collected by condensation in the following order: Petroleum ether, very volatile; 90 deg. (Baumé) gasoline; 88 deg. gasoline; 86 deg. gasoline; then naphtha, which averages 68 deg. to 69 deg., a mixture of all the volatile products heavier than the 86 deg. gasoline and lighter than the benzenes, which, in turn, are the heaviest of the series and the last to pass over through the worm and be condensed. It is understood, however, that recently the manufacture of 88 deg. and 90 deg. gasoline has been abandoned.

The lighter the product the larger the proportion of hydrogen it contains; and the heavier it is, the more carbon. The more carbon the greater will be the density and specific gravity. Petroleum ether, the very lightest of the naphtha series, has more heat units to the pound than benzene, the heaviest product, but in volume, gallon to gallon, odds would be strongly in favor of the benzene.

The following table will give a comparison of the heat values of automobile naphtha, kerosene, and alcohol:

	Specific Gravity.	Heat Units.
1 pound automobile naphtha	0.715	19,000
1 pound kersoene, 150 deg	0.800	18,500
1 pound alcohol 90 per cent	0.815	10,080
1 gallon automobile naphtha	....	100,300
1 gallon kerosene, 150 deg. (46 deg. Baumé)	....	124,275
1 gallon alcohol, 90 per cent	....	68,700

Table taken in part from SCIENTIFIC AMERICAN SUPPLEMENT, No. 1596.

One heat unit is sufficient power to raise the temperature of 1 pound of water at 39 deg. F. (at which temperature it is at its greatest density) one degree.

In the above table the heat values of the hydrogen and carbon are not given. But for the contained oxygen the heat value for the hydrogen in 1 pound of alcohol would have been 8,091 heat units, and for the carbon 7,565, or a total of 15,656, provided the alcohol was C_2H_6O.

In the destructive distillation of petroleum, after the crude naphtha is all driven off, the heat is increased to obtain the kerosenes. These are treated and redistilled, and in a similar manner to the lighter products, kerosenes of different gravity and fire test are obtained.

The crude naphtha took a very low heat to be driven off, while the kerosene took rather more, sufficient to drive off with it a considerable amount of coal tar. To rid the kerosene of this deleterious product, sulphuric acid and water is used for "washing," the tar being thus burned out, and unless great care is exercised some of the sulphur of the sulphuric acid, being set free, unites with the hydrogen, the result being the particular acrid smell of kerosene when allowed to stand for any length of time.

In the distillation of the naphthas a much lower temperature of the worm was necessary to condense it than when distilling kerosene. It is on account of the much larger percentage of carbon contained in kerosene, that it is so much slower to burn than naphtha. To make it explosive it has to be heated and more thoroughly vaporized by mechanical or other means. Kerosene takes less oxygen from the atmosphere, explodes more slowly, and the result, theoretically at least, is more power. If, however, there is insufficient oxygen, kerosene will smoke, soot, and smudge to an alarming extent, with a resulting deposit of free carbon on the walls of the cylinder, head, and piston. If electric ignition is used, this carbon soon "short-circuits" the current and ignition ceases. In a gasoline engine the percentage of air to vapor may vary several times as much as is allowable when using kerosene, and this is the main obstacle to the use of the latter, particularly with a variable load, as when slowing down, reversing, etc.

Kerosene engines which use the hot ball system of ignition, usually take a full charge of air at each induction stroke, or charge, and are regulated, if at all, by the amount of kerosene injected into the hot ball at each stroke. This usually begins to smoke before it ignites and is one of the chief reasons why kerosene engines practically always have smoky exhausts.

The length of time it takes to heat up the ball preparatory to starting and the heat which it radiates in a closed cabin are also two serious disadvantages in the marine kerosene engine. Practice has proven that it is necessary to utilize hot ball ignition to be at all successful.

Outside of economy, with possibly additional power, and less liability to danger from explosions within the boat, very little can be said of the successful manufacture of the marine kerosene engine for use in the United States at least, and its common adoption, even for commercial marine use, is within an extremely limited radius, and then by ultra-nervous owners, fearful of explosions. The freedom from such catastrophes as have been freely predicted by kerosene oil enthusiasts, even with almost no care exercised, either in installation or operation, can but prove that with more careful consideration of the importance of care in installing and operating, these almost fanciful dangers may be practically entirely eliminated.

Experience has proven that the best results are usually obtained when the load is full, nearly to the horse-power rating of the engine. An intermittent load, or an engine run continuously idle or with a minimum load, is much more likely to give trouble from excessive carbon deposits. For marine work, where the load is nearly always constant, the liability to smoke and the unpleasant odor from the exhaust should not be quite so marked as in stationary engines, for the speed flexibility exactions are here not so pronounced.

After carefully studying the results of manufacturers, the structural composition of kerosene, and the peculiar conditions present when used in marine engines, I have concluded that if ever kerosene is used successfully and is thus to become a competitor with gasoline, it will be when used in combination with a flexible suction gas producer, which will produce *absolutely* the same proportions of kerosene vapor and air, thoroughly mixed, so that it may be ignited by means of the electric spark. Whether or not my prediction proves true remains to be seen.

If, however, kerosene were to be used in automobile and marine engines, its price would advance even more rapidly than has that of gasoline. Kerosene may be quite safely transported, and much more cheaply too than gasoline. Its price here is something like two-thirds that of gasoline, while in England, France, Holland, or Australia the price of gasoline or petrol, as it is there called, is very much higher. At Wellington, Australia, the price of kerosene per imperial gallon is something like 50 cents, while gasoline retails for about $1.60.

Denatured alcohol may now be manufactured and sold, under certain restrictions, without the payment of a U. S. internal revenue tax, amounting to $1.10 per gallon on proof spirits, which consists of 50 per cent alcohol.

Alcohol of commerce, the grain product, is usually about 94 per cent pure, and dutiable at the rate of $2.07 per gallon. Absolute alcohol, that is, alcohol without any admixture of water whatever, is dutiable at $2.20 per gallon. The selling price of absolute alcohol is considerably higher than the 94 per cent commercial article, on account of extra cost of production. Absolute alcohol is much more volatile than 94 per cent, and likewise the 90 per cent grade, which it is proposed to denature by means of wood alcohol, etc., will not be nearly so volatile, or easily vaporized, as 94 per cent.

In the use of denatured alcohol, where practically no change in general construction becomes necessary, save possibly increasing the compression, as proposed by at least one authority, or decreasing it, as another urges, the conditions are somewhat changed.

Alcohol will not vaporize as readily as naphtha, and this will be more evident to the user if instead of 90 per cent subsequent dilution with water may have decreased its gravity to 80 per cent or less, and decreased its volatility, perhaps below any possibility of vaporization.

I am not so enthusiastic about alcohol until its use has become more universal, or at least the experimental stage has been passed.

In a recent interview, Prof. C. H. Lucke, of Columbia College, a recognized authority on denatured alcohol, and one of the experts employed by this government to investigate its manufacture abroad and its possibilities here, is said to have admitted that the use of denatured alcohol would not be particularly economical, as it would take two and one-fourth to three and one-half times as much alcohol as naphtha to get the maximum power. With gasoline at 20 cents and the denatured product at 34 cents per gallon, the latter would develop 10 per cent more power on alcohol costing from 72 cents to $1.19 than with 20 cents worth of gasoline.

As the power of alcohol depends upon its heat value, a comparison of the number of heat units in each may prove interesting. The heat value of alcohol, however, is that of 90 per cent, not commercial or 94 per cent, and the denatured product, owing to the admixture of wood alcohol, which may be 98 per cent pure, might increase these figures slightly.

One pound of 90 per cent alcohol contains about 10,080 heat units, while there are about 68,700 in a gallon. The specific gravity of 90 per cent alcohol is 0.815, and a gallon therefore weighs 6.815 pounds.

If it were possible to utilize the heat values of the hydrogen in the water which is used to reduce the alcohol to 90 per cent, the heat values given in the table would be slightly increased, but instead its presence would have probably the opposite effect.

There is no doubt but that an engine with higher compression would give more power, as, on account of the oxygen in the alcohol, not nearly so much need be supplied from the air with the accompanying nitrogen. Also on the principle of an English patent, a certain amount of water injected into the cylinder at each induction charge of gasoline vapor and air is said to increase the efficiency. This water may be a decided benefit, a slower expansion following the explosion, in the same or a similar manner as beforementioned when considering the increased power of kerosene over gasoline. This slower expansion, if proven to be true, would considerably decrease efficiency at high speed.

It is quite likely that there will be continued use and advances in the price of gasoline. The kerosene proposition, while holding out some alluring possibilities, is to my mind a decided improbability for use in marine engines.

While the oil fields of the United States are situated so convenient to the consumer, the use of alcohol will not be general for some time, or until its price compares much more favorably than it does to-day.

From which it can be but reasonably concluded that gasoline, with all its danger, real or fancied, will continue to be the popular fuel for some time. It is safe when intelligently used and when the installation of the engine, tank, and piping is properly made. To this end, no trouble or care should be spared at the expense of safety to operator, passenger, or guest. The federal authorities have already passed a law for their better protection, making licenses obligatory for operators when craft so power-equipped are used for the transportation of passengers for hire, and naturally further legislation may be expected, looking to the boat itself, the engine installation, and fuel appurtenances, the object being to render their use more safe, the boats themselves being put under proper surveillance, to minimize liability of danger and prevent avoidable accidents.

POULSEN'S TELEPHONIC MESSAGE RECORDER.

THE principle of the latest system devised by V. Poulsen, by means of which telephonic messages may be recorded or stored, is based on the magnetic excitation of paramagnetic bodies. A paramagnetic body, such as a steel wire or ribbon, when moved past an electromagnet connected with an electric or magnetic transmitter, such as a telephone, is magnetically excited along its length in exact correspondence with the signals, messages, or speech delivered to the transmitter, and when the magnetically excited wire is again moved past the electromagnet it will reproduce the messages in a telephone receiver connected with the electromagnet.

The invention finds practical value for telephonic purposes by providing a suitable apparatus in combination with a telephone in which communications can be received when the subscriber is absent, and which, upon his return, can be repeated.

The apparatus embodies a clockwork mechanism to furnish movement of the recording parts. A bow-shaped frame (Fig. 1) consists of a piece of tubing bent into shape and having its ends connected by an arm (e'), mounted to turn on a spindle. The upper end of the bow has a bearing at the middle of the frame, by means of a short stud, which passes through the bow and enters the frame (b). The rotary mo-

tion is imparted to the bow by means of clockwork. A fixed ring (48), carrying two annular electrical contacts (49) on its upper surface, is arranged immediately below the arm (e'), and the arm is provided with a spring-mounted pin adapted to be forced into connection with both of the electrical contacts for the purpose of electrically connecting them together.

On the surface of the cylinder (d) is wound a steel wire (g) in a uniform helix. On one of the arms of the bow is placed a sleeve (f), adapted to slide freely up and down on the bow. This sleeve has pivoted to it a magnet holder. The magnet holder is provided with a tailpiece, which is normally pressed upon by a spring, tending to force the poles of the magnet out of contact with the wire (g).

When the bow (e) rotates it will carry the drum (17) with it; but, owing to the action of the brake (18) and the wings (16), there will be a certain amount of lagging on the part of the drum, which will be permitted by the twisting of the wires (15).

The clockwork is normally prevented from rotating by the weight of the armature (11), which acts upon the brake, as shown in Fig. 1. The brake is released by the electromagnet (10), in a circuit with battery (E) and a cut-out (14), attached to the frame (b).

The apparatus so far described is a phonograph, the operation of which may now be referred to.

Let it be assumed that speech or signals are being electrically transmitted over the circuit containing the magnet, that the sleeve is at the lower end of the bow, and that the machine is started by closing the circuit of magnet (10). The bow immediately commences to rotate around the cylinder. When the speed is sufficient, centrifugal force acting upon the weight (p) will cause the core of the magnet to be thrown into contact with the wire (g), whereupon the sleeve will be caused to slide upward upon the bow, owing to the spiral arrangement of the wire on the cylinder. At the same time the undulations of current in the circuit of the magnet will vary the magnetism of the magnet, which variations will be successively imparted to the wire (g). The message may continue until the sleeve reaches the elevation of the cut-out, whereupon the finger on the sleeve strikes the cut-out and swings it to one side, thus opening the circuit of magnet (10). To reproduce the message which has thus been magnetically recorded, it is only necessary to put a receiving telephone into circuit with the magnet instead of the transmitting telephone and then start the machine again, whereupon the sleeve will travel up on the bow and the poles of the magnet will traverse the wire (g), the successively varying magnetic condition of which will react upon the core of the magnet and cause the same undulations of current to be sent over the line to the receiving telephone as were previously sent over the line to the magnet from the transmitting telephone.

The connection of the apparatus to a telephone is shown in Fig. 2. A switch (19) is provided, having four terminals (38), (39), (42), and (43). These terminals can be connected with each other in three different ways by means of the switch lever. In the position shown in the diagram the two terminals (38) and (39) are connected together. This position establishes the circuit for the ordinary use of the telephone. The two conductors (35) and (40) constitute the outgoing and return lines.

If the switch lever is so adjusted as to connect the two terminals (38) and (42), the apparatus can then be used as a phonograph, and the transmitting telephone belonging to the same station can then be used. To clearly explain this, the course of the current should be followed when the terminals (38) and (42) are connected. When the subscriber turns the crank handle of his induction apparatus, a current will pass through the outer coil of the induction coils (R). A current is then induced in the inner coil of the induction coils (R); the electromagnet (22) is thus excited and the armature attracted, whereupon a weighted block (41) is released and falls. By this means contact is made between the contact piece (28) and spring (29), whereby the local circuit of the battery (E) is closed through the electromagnet (10), which attracts the armature (11), (Fig. 1), so that the clockwork is set in motion and the bow rotated. The sleeve, which has been resting upon the pin, begins to rise, and the connection between the contacts (49) is broken. The contact (23) consequently exists only for an instant, so that the circuit of the conductors (20), (21), (22), (23), (24), and (25) is open during the operation of the clockwork and apparatus. Now, during the rise of the sleeve, and while the electromagnet is in contact with the steel wire (g) in the manner described, the subscriber can speak into his transmitter, and spirally-wound steel wire will be correspondingly magnetized. The matter thus fixed can now be transmitted over the line by using the third connection—that is, by connecting the terminals (42) and (43) of the switch (19). If, for example, the message, "The subscriber is not at home, but will return at 4 o'clock," is fixed to the steel wire, the subscriber at the transmitting station now hears through his receiver the message fixed to the steel wire, and knows that in order to speak with the subscriber at the receiving station he must call up at 4 o'clock.—The Electrical Magazine.

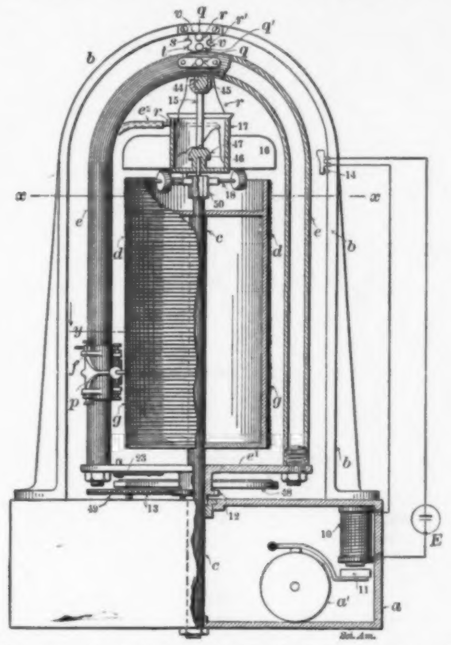


Fig. 1.—POULSEN'S TELEPHONIC MESSAGE RECORDER.

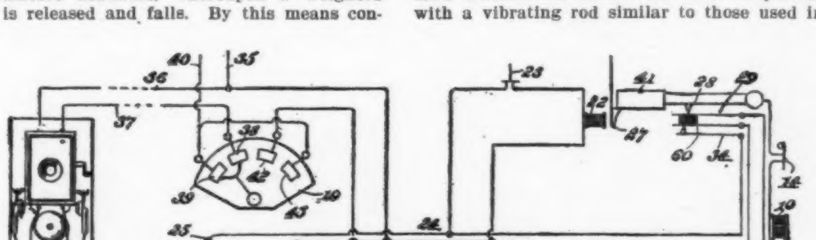


Fig. 2.—CONNECTIONS OF POULSEN'S MESSAGE RECORDER IN TELEPHONE CIRCUIT.

ELECTRIC SLEEP OR ANÆSTHESIA.

By Dr. G. H. Niewenglowski.

Prof. Stéphane Leduc, of the medical school of Nantes, whose remarkable experiments in the production of artificial cells are well known, has for several years been studying, both experimentally and clinically, the physiological and therapeutic effects of intermittent electric currents of low voltage and the action of electric currents on the brain. This article is devoted to a summary of the principal results obtained by Prof. Leduc and by Dr. Louise Robinovitch of Philadelphia.

The apparatus required in Prof. Leduc's experiments with intermittent currents of low tension and moderate frequency comprises a source of continuous current, a device for reducing the voltage, an interrupter of special construction by which the number of interruptions and the duration of the partial currents can be modified at will, a voltmeter and a milliamperemeter. It is convenient to insert also in the circuit an ordinary interrupter or key by which the circuit can be suddenly opened and closed.

The special interrupter is of capital importance. Max Kohl's rotary mercury jet interrupter may be used, but the sleep produced by it is uneasy and disturbed by nervous twitchings because of the inequalities of the interruptions effected by the jet of mercury. Miss Robinovitch made use of a simple interrupter with a vibrating rod similar to those used in electric bells. But the best results are obtained with the interrupter devised by Prof. Leduc.

The experiment is conducted in the following manner: On a portion of the head of the animal—a dog or a rabbit—the hair is clipped very short and an electrode applied. This electrode, which is covered with a metal plate and held in place by a muzzle, is formed of absorbent cotton saturated with a warm one per cent solution of common salt and is connected with the negative pole of the battery. A larger electrode connected with the positive pole is applied to a clipped spot on the back of the animal, near the tail.

The interrupter is started and the voltage is increased until the animal is seized with general muscular contractions, falls over on its side and stops breathing. The voltage is then gradually diminished until respiration is re-established, which occurs at the same voltage in dogs and rabbits. This voltage varies from 16 to 30 volts, according to circumstances, and the amperemeter indicates 2 milliamperes when the intermittent current is employed and 22 milliamperes when the interrupter is stopped so that the current is continuous. This shows that the intermittent current is actually flowing during one-eleventh of each period which, for the frequencies employed, corresponds to from 1/1,500 to 1/2,000 of a second.

From 90 to 110 interruptions per second are found to be the most effective for producing sleep. If the period is longer or shorter than this the animal is agitated and subject to more or less marked muscular twitchings, often extending throughout the body.

Dr. Robinovitch after experimenting with various sources of electricity found that in order to produce tranquil sleep it was necessary to employ accumulators for the current which traverses the animal and to operate the interrupter by a current from a separate source.

Electric sleep has been produced several times in human beings. Prof. Leduc first submitted himself to experiment in 1902. He published in the Archives d'Electricité Médicale of July 15, 1903, an account of his experience, from which the following extract is taken:

"The sensation produced by the excitation of the superficial nerves, though disagreeable, is quite endurable. It passes away in time, like the sensation produced by a continuous current, and after attaining a maximum diminishes in spite of the increase in voltage. The face is red; slight contractions of the muscles of the face, neck, and fore arm and a few fibrillar trepidations occur. A sensation of formication ensues, at first in the fingers and hands, then in the toes and feet. The center of speech is first inhibited, then the motor centers are inhibited so completely that the subject is unable to move even in response to the most painful stimuli, nor can he communicate his sensations to the operators. The limbs, though not entirely relaxed, show no rigidity. There are a few groans, which are caused, not by pain, but apparently by excitation of the muscles of the larynx. In our experiments the pulse remained entirely unaffected, though the respiration became somewhat labored. Even under the maximum current I heard, as if in a dream, the words of my assistants and was conscious of my inability to move or speak. I felt contact, pinches, and pin pricks in the arm, but the sensation was blunted like that of a benumbed limb. The most unpleasant impression was the feeling of the gradual dissociation and successive loss of the faculties. This impression was identified with that of a nightmare in which the sleeper finds himself threatened by some frightful peril but feels that he can neither make a movement nor utter a sound."

This state of electric narcosis can be maintained for a long time. Dr. Robinovitch succeeded in one case in prolonging the electric sleep to eight hours and twenty minutes without injuring the animal. In connection with this case she emphasizes the fact that electric narcosis of long duration is borne better, by rabbits at least, than narcosis produced by ether or chloroform. From the beginning of the administration of ether or chloroform rabbits are in danger of death from cardiac syncope and it is never safe to continue the administration longer than two hours.

In electric sleep the pupils are not dilated as in epilepsy, but are contracted. The frequency of respiration is very nearly normal and the temperature is slightly below the normal. The arterial pressure is always increased. The same phenomenon is observed in narcosis produced by other agents. It always occurs in animals under chloral and is sometimes observed in chloroformed rabbits.

This elevation of arterial pressure is noteworthy, for if, instead of a voltage sufficient to produce merely electric sleep (inhibition of will and sensation), a voltage high enough to cause either an epileptic attack or electrocution (inhibition of respiration) is employed, the elevation of arterial pressure, when it occurs, is slight and evanescent.

The Leduc current makes possible the painless electrocution of animals by gradually raising the voltage until inhibition of will and sensation is succeeded by inhibition of respiratory movements, which is soon followed by stopping of the heart.

There is a striking contrast between the effects of these currents and the spectacle of an animal electrocuted by induced currents. In animals killed by the Leduc currents Dr. Robinovitch never found any apparent lesion of the nervous centers, while serious lesions are recorded in the reports of the judicial electrocutions which have taken place in the State of New York.

The researches of Prof. Leduc prove that intermittent electric currents of low voltage are capable of producing instantaneous and complete inhibition of the cerebral hemispheres, without causing apparent pain or interfering with the centers of respiration and circulation. The result is a calm and regular sleep, which can be prolonged for several hours, and a general and complete anæsthesia. Sleep is induced rapidly on the application of the current and ceases soon after its discontinuance. There are no after effects. Prolonged and repeated electric sleep produces no apparent injury to the health of the animal.—Translated for Scientific American Supplement from Cosmos.

THE THEORY AND ACTION OF A 100-MILE WIRELESS TELEGRAPH SET.—V.*

By A. FREDERICK COLLINS.

To obtain the best results with the 100-mile wireless telegraph equipment previously described in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 1605, the operator should understand the theoretical action as well as the practical working of the instruments employed.

Probably a greater number of transformations and conversions of energy take place during the transmission and reception of a wireless telegraph message

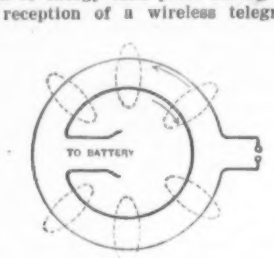


Fig. 1.—Heavy Line Indicates Electric Current in Primary Coil. Light Line Indicates Induced Current in Secondary Coil. Dotted Lines Indicate Closed Magnetic Lines of Force Set Up by Primary Current and Producing Induced Secondary Currents.

than is to be found in any other application of electricity, since there are no less than eight changes involved at the sending end before the direct continuous current is transformed into electric waves and five changes at the receiving end in the conversion of the electric waves into sound waves.

In virtue of these changes taking place at two widely separated points, and yet simultaneously, the manner in which the energy is manifested and the movements of the mechanism are not only interesting from a theoretical viewpoint, but an intimate knowledge of the processes is quite essential to the practical working of the apparatus. Beginning then with the transmitting end and following step by step the successive actions, it will be found that (1) the low-voltage continuous current generated by the primary cells flows through a circuit in which is included the key, the interrupter, and the primary winding of the induction coil; when this circuit is closed by the key the automatic make-and-break device changes the direct continuous into (2) a direct interrupted current; in flowing through the helix of wire forming the primary coil this intermittent current is transformed into (3) magnetic lines of force.

Next in sequence, the lines of magnetic energy induce (4) alternating currents of high potential, but low amperage and low frequency, in the turns of wire forming the secondary coil which are delivered at the terminals of the latter; these alternating currents are impressed upon the opposite coatings of the battery of Leyden jars and (5) charges them to a value commensurate with the length of the spark-gap; the jars thus charged to their critical capacity break down the insulating film of air separating the spark-balls and releasing the pent-up energy it produces (6) electricity in locomotion or high-frequency currents of high potential and low amperage in the closed oscillation circuit; these oscillations are then communicated to the open aerial wire circuit which is coupled directly with the closed circuit, and finally the energy of the oscillations is emitted into the surrounding space in the form of (7) electric waves.

These varied and remarkable results are secured by the following functions of the transmitting apparatus: On closing the primary circuit the low-voltage direct current is made and broken several hundred times per minute, and this periodically interrupted current flows, of course, through the primary of the coil. As the inductance of the primary coil is considerable, the voltage of the current is raised above its normal value, and

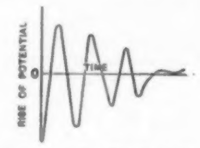


Fig. 5.—Damping of Oscillations in Open Circuit.

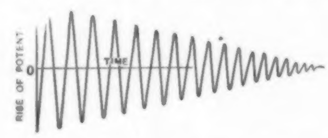


Fig. 6.—Damping of Oscillations in Closed Circuit.

were it not properly taken care of, it would produce an excessive spark at the interrupter contacts. To counteract the inductance effects a condenser is shunted around the contact points of the interrupter; when the contact points are together the full current strength flows through the primary circuit, which is then closed and the condenser is inactive; the moment, however, the contact points are drawn apart and the circuit is broken the current flows into the condenser until it is charged. When the contact points again make the circuit the energy stored up in the condenser is discharged through the primary circuit and supplements the current flowing through the inductor. In an interrupter where the circuit is quickly broken, the condenser may be much smaller than where the contact points separate more slowly. This is due to the time required for the inductance of the coil to increase the voltage, which is very much less than where the break takes a longer time.

In virtue of the well-known laws of electro-magnetic induction, the greater portion of the electric current flowing through the primary coil is transformed into magnetic energy in the form of curved lines as shown in Fig. 1, and as each electric impulse changes its current strength from its highest to its lowest value, and *vice versa*, thus completing the cycle of variation, the lines of magnetic energy contract and expand accordingly.

The object of inserting a soft iron core in the primary coil is to concentrate the magnetic energy in a space approximating the diameter of the coil. As is well known, iron is many times a better conductor of magnetism than is air or the non-magnetic metals, and though the magnetic circuit is completed through the space occupied by the secondary turns of wire, practically all of the magnetic flux is confined to the immediate vicinity of the core in passing from one pole to the other, as in Fig. 2.

When the expanding and contracting magnetic lines of force thread through and intersect each turn of wire of the secondary coil the energy is transformed into electric currents and the relative values of the electromotive forces set up in the primary coil and that impressed on the secondary coil are directly proportional to the number of turns of wire on the primary and secondary coils except for a small loss in transformation, hence the output of energy at the terminals of the secondary is practically the same as the intake of the primary coil.

In a simple secondary system as shown in Fig. 3 the high-potential, low-amperage, and low-frequency current of the secondary coil is employed to charge the aerial-wire system direct. In this case, one of the terminals of the secondary coil is connected with one side of the spark-gap and the lower end of the aerial wire, while the opposite terminal of the secondary is connected with the complementary side of the spark-gap and the upper end of the earth wire.

When the induction coil is in action the opposite arms of the open oscillation circuit—as the aerial wire, spark-gap, and earthed wire are termed—are charged with the opposite electricities, exactly in the same manner as a condenser is charged, and this being true when the potential difference of the opposite arms has reached a certain critical potential they will discharge across the spark-gap, thus setting into locomotion the stored-up energy, and, hence, giving rise to high-potential and high-frequency currents that surge through the aerial wire system from its top to the surface of the earth, and, rebounding like a rubber ball, surge to the top again, at the rate of hundreds of thousands of times per second.

It may be asked how these electric oscillations can pass through the spark gap, forming as it does an actual physical break in the open-circuit conductor, and it may be further asked why these electric oscillations do not follow the alternative path offered by the secondary winding of the induction coil. In answer to the first query it will only be necessary to suggest that when the air forming the insulating gap is disrupted by the rushing together of the opposite charges of electricity it is burned out and the gap remains heated for a brief period of time, thus reducing its resistance to an almost negligible value.

Naturally, the oscillations set up follow the path of the least resistance—not necessarily the least ohmic resistance (for a wire of any metal offers but little ohmic resistance to high-frequency currents, as the latter do not sink into the body of the wire but remain on the surface), but the greatest opposing resistance offered to such currents is inductance, and as the secondary of an induction coil possesses not only a very high ohmic resistance, but a high inductance as well, it prevents the oscillations from surging through it, hence the oscillations are confined almost entirely to the oscillation circuit.

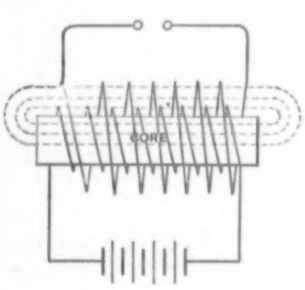


Fig. 2.—Magnetic Circuit Completed Through Soft Iron Core.

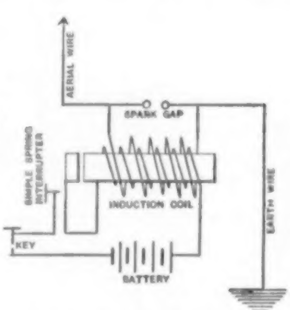


Fig. 3.—Simple Wireless Sending System.

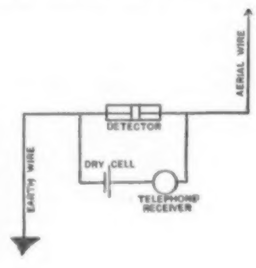


Fig. 7.—Simple Open Resonating System.

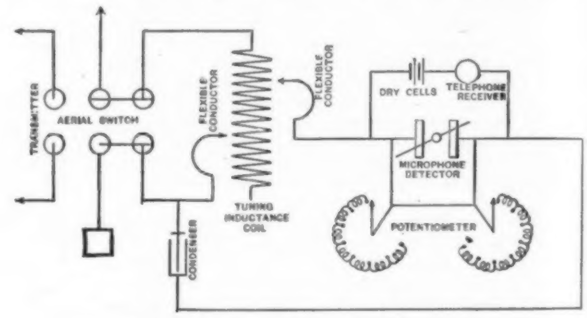


Fig. 8.—Compound Resonating System.

The final transformation of the energy of the transmitting system takes place when the high-frequency currents oscillate through the aerial wire and are damped out in the form of electric waves. The action involved in this interesting process is analogous to that of a tuning fork sending out sound waves. When a fork is struck the mechanical energy imparted to it by the blow sets its prongs to vibrating. This vibration would continue indefinitely if it did not have to overcome the resistance offered by the air, for every to-and-fro movement sets this medium into motion by imparting to it a series of longitudinal thrusts and which are termed sound waves.

Likewise, when an aerial-wire system is endued with high-frequency currents the electrical energy oscillating through it is damped out by the opposing resistance of the ether in which it moves and in this rapid to-and-fro movement it sets the medium into a transverse state of vibration which is termed, for convenience, electric waves. It is the propagation of these electro-magnetic vibrations or ether waves that form the connecting medium between the transmitter and the receptor.

So much for a simple open-circuit radiator, but the transmitter under consideration is of a more recent type and combines a closed oscillation circuit with an open circuit as illustrated in Fig. 4. In this case the closed circuit includes the spark-gap, an adjustable condenser, and a variable-inductance coil; the closed circuit is connected directly with or coupled to the open oscillation circuit formed by the aerial wire and the earthed terminal.

In an open circuit the oscillations are damped out very quickly, sometimes in two or three swings, as shown in Fig. 5, while in a closed circuit the oscillations, though still of a periodic character, are more persistent as indicated in Fig. 6. A combination of open and closed circuits makes it possible to obtain a more persistent oscillation in the aerial wire than would otherwise be possible, for in a closed circuit the damping factor is not so large, and if the closed and open circuits are tuned so that the periods of oscillation are

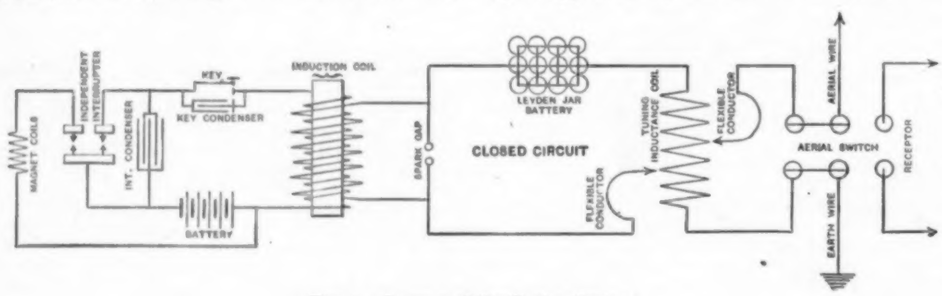


Fig. 4.—Compound Oscillation System.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT. This article should be read in connection with the following articles by the same author: "The Design and Construction of a 100-Mile Wireless Telegraph Set" (SUPPLEMENT 1605); "The Location and Erection of a 100-Mile Wireless Telegraph Station" (SUPPLEMENT 1622); "The Installation and Adjustment of a 100-Mile Wireless Telegraph Station" (SUPPLEMENT 1623); "The Adjustment and Tuning of a 100-Mile Wireless Telegraph Outfit" (SUPPLEMENT 1624).

identical then the maximum efficiency will result, in so far as the radiation of electric waves is concerned.

Having followed the theory and action of the transmitter from the generation of the initial current to the emission of the electric waves, it is next in order to reverse the procedure and ascertain just what takes place when the incoming waves impinge upon the antenna of the receiving station.

At the receiving end the successive actions that take place are the transformation of electric waves into (1) electric oscillations in the open and closed circuit, where they operate the detector, whose functions are the equivalent of a delicate relay. The energy of the high-frequency currents is by this device exchanged for (2) a direct current of low voltage generated by the dry cells in the local circuit; when this current flows through the telephone receiver it is transformed into magnetism, and the magnetic energy, acting in turn on the diaphragm of the receiver, is converted into (4) mechanical energy, and this again into (5) sound waves.

In a simple open-circuit resonating system, as shown in Fig. 7, the coherer or other detector is placed in circuit between the aerial wire and the earthed wire; a local circuit is formed by connecting the opposite terminals of the detector in circuit with a dry cell and a telephone receiver.

That portion of the electric waves which impinge upon the receiving aerial wire is transformed into electric oscillations, and assuming that the capacity, inductance and resistance of the resonating circuit is equal to these co-efficients of the oscillation circuit the complementary stations will be in syntony and the frequency of the oscillations produced in the receiving aerial will be exactly equivalent to the oscillations which gave rise to the waves at the transmitting station.

In the resonating system employed in the 100-mile set the oscillation circuits are compounded, namely, an open and a closed circuit are connected with each other by a direct coupling, as shown in Fig. 8. When the oscillations set up in the aerial wire reach the tuning coil, the inductance interposed between the aerial and the earth wires is so large that it impedes the progress of the currents and causes practically all of the current to flow through the detector, whence the energy is directed to the earth and surges back and forth until the cycles of oscillation have reached zero.

The energy of the oscillations in passing through the variable resistance of the microphone detector causes it to drop from its normally high resistance—offered by the small surfaces of the steel needle resting on the sharpened edges of the carbon—to a very much lower value. This variation in the resistivity of the detector is due to the cohesion produced between molecules of steel and carbon which is brought about by a difference of potential established by the oscillations; this is followed by an electric field, which in turn is succeeded by cohesion, and if the oscillations are strong enough the edges of the opposed molecules will be welded together.

The voltage developed by the dry cells in the local circuit is varied by means of the 10 and the 150-ohm rheostat, or potentiometer, until the electromotive force just fails to break down the resistance of the detector. Now, when the high-frequency current oscillates through the closed circuit the cumulative electromotive force finally coheres the needle and the carbon on which it rests.

This accomplished, the direct current from the dry cells easily flows through the detector and local circuit and energizes the magnetic coils of the telephone receiver, when the diaphragm is attracted to their polar projections. Instantly the oscillations cease flowing through the detector, cohesion ceases and the high resistance is restored, this self-righting quality being a characteristic of both carbon and steel. This action prevents the current in the local circuit from flowing through the detector, and hence the magnets of the telephone receiver are de-energized; this releases the diaphragm and it returns to its normal position by its own elasticity, the sudden movement sending out sound waves resulting in a click which is interpreted by the operator as a dot of the alphabetic code, or if there is a succession of these sound waves emitted it is read as a dash.

MORTISE AND TENON JOINTS.

A TENON is a tongue or projection of reduced size formed at the end of a piece of wood, and a mortise is a corresponding slot or recess cut to receive it in the side of another piece. The end of the tenoned piece thus fits into the mortised piece, preventing lateral movement of the parts in relation to each other, permitting them to meet in the same plane, and forming a joint which can easily be held together by glue, pins, or other means.

These joints are very common in carpentry and joinery, and in a less degree in pattern work. They are suitable for framed articles where the members are long but compact in section. For broad surfaces they are never used, and for long-edge joints only when end grain meets side grain in which mortises can be cut; but even then they are rarely employed.

There are many varieties of mortise and tenon joint, but the differences are chiefly in the shape and proportion of the tenons in relation to the member they are formed on. There are first two important differences in the length of tenons. In one, the tenon, and consequently the mortise, cuts through the mortised piece, the end of the tenon usually being flush with the external face. In the other, the tenon only penetrates to a short distance, the mortise being correspondingly shallow. Both these forms are very commonly employed, the first being a thorough, or ordinary, tenon, the latter a stub, or stump, tenon. The thorough tenon makes a stronger joint; but there are a number of considerations which make the stub tenon quite as popular, even in work where strength is the first consideration.

The main function of the stub tenon in heavy work is usually not to hold the parts together, but to prevent their getting out of place laterally, the holding together being accomplished in some other way. In other cases, though not very often, a thorough tenon would be so long that a shorter one would hold equally well, or quite as well as necessity demanded. Another consideration is the weakening effect of a deep mortise, which diminishes the strength of the piece it is cut in.

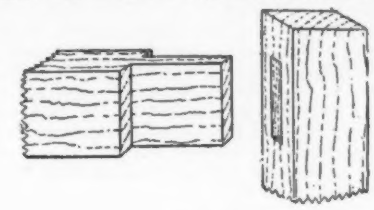


FIG. 1.

In its simplest form an ordinary tenon is proportioned as in Fig. 1. It is made the full width of the piece it is formed on, and of one-third the thickness. When the width exceeds five or six times the thickness, it is advisable either to reduce the width of the tenon, or to divide it into two parts. The former plan often has to be adopted in cases like Fig. 2, where the mortise occurs at the extremity of the member, and it is desired to avoid cutting through the end grain. The tenon, then, even if well proportioned in itself, is reduced in width as shown, generally with a short stump called a haunch, *A*, but sometimes the cut-away portion extends completely to the shoulder. The advantage of the haunch is that it prevents warping or twisting of the members in relation to each other, as completely as if the tenon extended the full width. Fig. 3 shows how the haunch may be tapered to nothing at the top, so that it will be invisible when the parts are together. This slightly reduces its efficiency. In Fig. 4 a pair of tenons are shown with a haunch between. In this case the piece is so wide that a single tenon running completely across would be no stronger, and would be more likely to cause trouble through warping and shrinkage than when its middle part is removed as shown. The mortised member, on the other hand, is decidedly stronger with the mortise divided than it would be with one long mortise for a single tenon. The opposite course might be adopted of having a single reduced tenon in the middle with haunches on each side, and circumstances sometimes necessitate this; but such a joint would not be so secure as one with a tenon at each end.

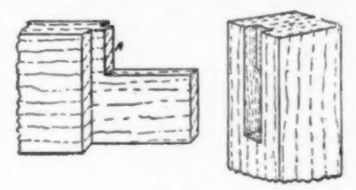


FIG. 2.

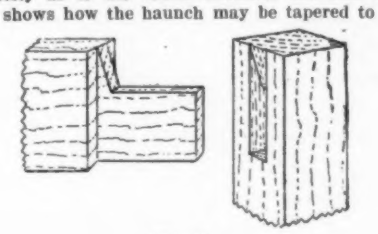


FIG. 3.

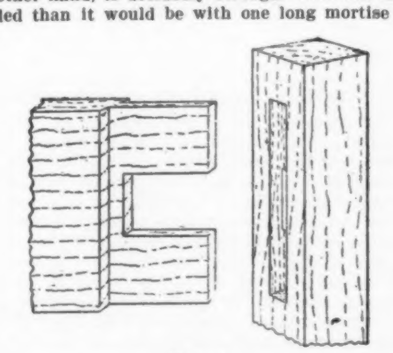


FIG. 4.

A stub tenon is shown in Fig. 5, at *A*. Its length depends on the proportions of the parts, and on other circumstances; but it is seldom made to penetrate far. At *B*, Fig. 5, a double stub tenon is shown. These are employed to prevent twisting when the thickness of the parts is considerable. Being divided in this way, the mortised part is kept a great deal stronger than it would be if an equally effective single tenon was employed. A point to be remembered in cases of this kind is that the longer way of the mortise should always run with the grain of the wood. Double tenons, therefore, are often necessary, where, if only proportions had to be considered, a single tenon at right angles to the grain would be simpler.

Fig. 6 *A* is a case where the tenon is not haunched, as in Fig. 2. It is not so often employed as the latter, and, of course, cannot be wedged, but must be screwed or pinned. It is more suitable for heavy work than for light; but in many cases a half-lap joint would be employed in preference to it. Fig. 6 *B* shows a stub tenon for parts meeting at an angle. A thorough tenon in such cases is seldom employed. There are numerous other slight variations of the form of stub shown. Very often the tenoned timber is notched into the surface of the other as well as tenoned.

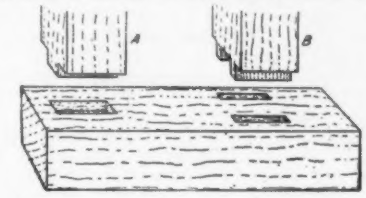


FIG. 5.

When mortise and tenon joints are not held together by external attachments, they are secured either by pins or wedges, and in joinery and small work are usually glued. In very light work glue alone is often relied on; but when this is not sufficient wedges are generally employed as well. Pins are better adapted for rough work, either with or without glue. Wedges hold the parts together by being driven either into, or alongside of the end grain of the tenon, making it club or dovetail shaped, the mortise being tapered to suit, so that the parts cannot be withdrawn while the wedges are in place. To make a secure joint, therefore, glue should be used with wedges. In Fig. 7 *A* an ordinary joint is shown with wedges partly driven in. The mortise is cut slightly larger, and tapered to receive them, and the glue holds them to the tenon after they are driven. The ends, of course, are trimmed off flush in finishing the work. In cases where extra security is required the wedges are driven into saw-cuts in the tenon itself. Sometimes four wedges are inserted, but two is the usual number.

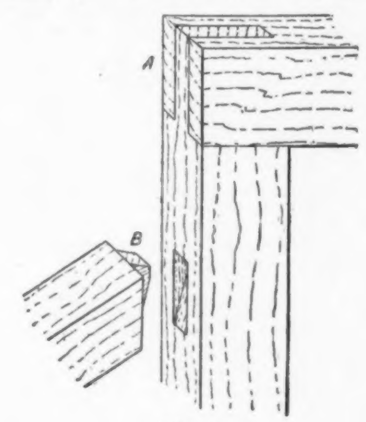


FIG. 6.

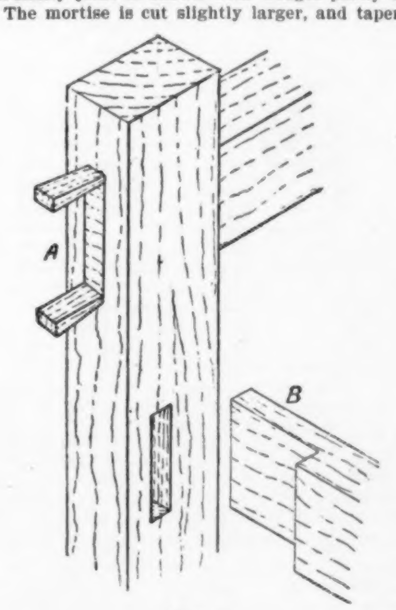


FIG. 7.

Fig. 7 *B* is a bare-faced tenon. This differs from an ordinary tenon in being shouldered from one face only. It is employed chiefly for thin rails which have to be made flush on one side with the posts they are tenoned into.

Fig. 8 shows how a stub tenon is fox-wedged. The wedges in such a case cannot be inserted after the

parts are together, so they have to be forced home by the closing of the joint. Generally, however, stub tenons are not wedged. Fig. 8 also shows how the saw-cuts, both in stub and ordinary tenons, should be slightly out of parallel with the tenon, to lessen the risk of withdrawal.

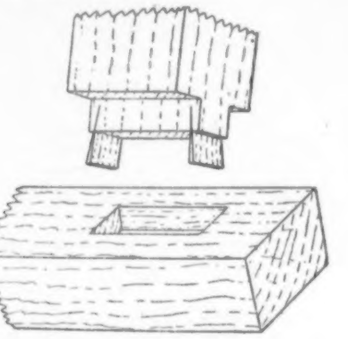


FIG. 8.

When pins are employed for holding the joint, they are inserted from one face of the work, at right angles to the direction in which wedges are used. Screws or nails are often employed in this way, but more commonly wood pins or pegs, roughly pared to octagonal section, with a slight taper lengthwise, which are glued and driven into holes bored for them. Usually they do not go completely through the parts, but remain visible only from the face they are driven in at. When pins are used, they are made to assist in pulling the parts together by draw-boring; that is, by making small holes in the tenon slightly out of center with the larger ones in the side of the mortise where the pins are entered. The work is usually cramped together before the pins are inserted, so that their function is not so much to pull the parts together as to maintain them so when the cramps are removed.

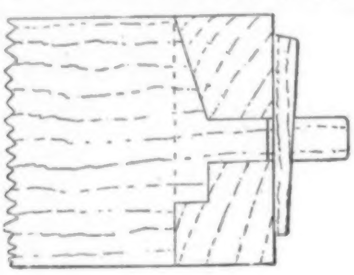


FIG. 9.

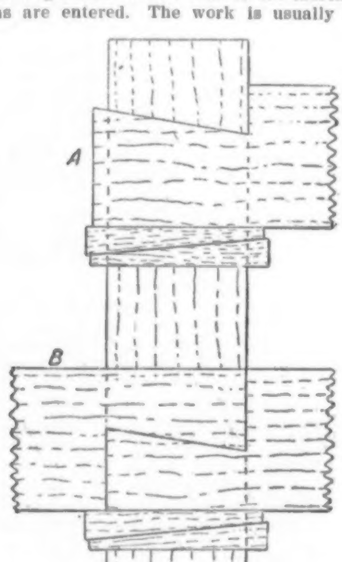


FIG. 10.

In some joints the end of the tenon is made to project considerably beyond the mortise, and a tapering pin is driven through the tenon only, as in Fig. 9. In such a case no glue is used, but the pin itself pulls and holds the joint together as tightly as may be required, and also permits it to be taken apart again by knocking the pin back. Fig. 9 is called a tusk tenon, and is employed for uniting heavy timbers which meet in a horizontal plane, the joint being designed specially to afford the maximum support to the tenoned end, with the minimum weakening of the mortised timber which supports it. As a beam is strained least in the central plane, it is only in that part that the tenon is allowed to pass through. Below the root of the tenon a short tusk is formed to prevent its getting sheared off, and it is similarly strengthened above by a projection which tapers to nothing at the top, in order to cut as little as possible from the mortised beam. The weight of the tenoned timber is carried partly by the portion the tusk rests on, and partly by the longer support in which the slender tenon bears. In some cases, when the supporting beam is wide, or when timbers enter on both sides, the tenon is not carried through, but held by a pin inserted through a hole in the mortised timber. All the parts of a tusk tenon are of the same width as the timber they are formed on.

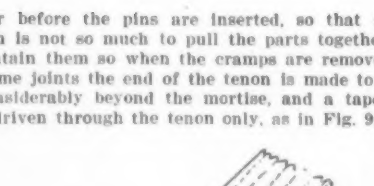


FIG. 11.

Fig. 10 *A* and *B* show dovetailed tenons held in place by folding wedges. In *A* one timber only is tenoned into the post, which is usually thicker than the timber that enters it. In *B* two ends meet, entering the mortise from opposite sides. These joints are employed more for work which has to be taken apart again than for fixtures. They are suitable when the timber in which the mortise is cut is thick, and the tenoned pieces thin. The latter, in fact, are generally not, strictly speaking, tenoned at all, but enter at their full thickness, and are dovetailed on one edge. Stub tenons also can be secured in this way.

Fig. 11 is an open mortise and tenon with shoulders mitered instead of square, like Fig. 6 *A*. It is, of course, not so strong as the latter, and is mitered for appearance. In cases where only one face shows, its strength is often increased by mitering the front only, and leaving the back shoulder square.

In large, well-equipped shops, mortises and tenons are cut by machines. By hand, mortises are partly bored out with a bit, and finished to the lines with a mortise chisel, or they are cut by chisel and mallet alone. Tenons are sometimes sawn to the line, but more frequently their shoulders are finished with a chisel, and their faces with a rebate-plane. Scribed and gaged lines are used everywhere in preference to pencil. The thicknesses of tenon and mortise are gaged with a mortise gage, which marks both lines simultaneously. The shoulders of the tenon and ends of the mortise are marked with square and scriber. If the tenon is a thorough one, it should be long enough to allow for dressing off after it is in place. A stub tenon should be a trifle short in its mortise to insure a close fit at the shoulder. The latter should be slightly undercut to insure close contact at the exterior.—English Mechanic and World of Science.

WEIGHT OF MAN ON THE PLANETS.

If the planet Mars is really inhabited, the people who live there must be an exceedingly nimble race. The average weight of a man is about one hundred and forty pounds, but the force of gravity on Mars is so much less than on the earth that the hundred-and-forty-pound man would weigh only fifty-three pounds if he were transported there. With such light weight, and still retaining the same strength, an individual would be able to run with the speed of an express train, go skipping over ten-foot walls, and do various other extraordinary things. On the moon, a man would be even lighter.

But on the sun, our hundred-and-forty-pound man would have his troubles. Instead of being an airy individual, he would weigh in the neighborhood of a ton and three-quarters. He would probably have the greatest difficulty in raising his hand, for that member would weigh about three hundred pounds.

According to scientific computation, a man who on the earth weighs one hundred and forty pounds would on the other celestial bodies weigh as follows:

	Pounds.		Pounds.
Moon	23	Uranus	127
Mars	53	Earth	140
Venus	114	Saturn	165
Mercury	119	Jupiter	371
Neptune	123	Sun	3,871

EIGHTEEN HUNDRED YEAR OLD BACTERIA.*

DURING the bacteriological examination of the contents of an old Gallic-Roman grave in the vicinity of Troussepoi, in Vendé, where a considerable number of such graves may be found, a most remarkable discovery was made. In the shaft of the rather deep grave, whose contents were entirely undisturbed, a large number of objects was found, which prompted the conclusion that in all probability it had been built in the second century after the birth of Christ. Besides the remains of previously burned corpses, the grave contained a number of skeletons of domestic animals, which had been placed therein without previous burning. All these remains, as well as the ornaments buried with them at the time, were enveloped in a rather strong layer of slime, which was bacteriologically examined by Dr. M. Boudoin. He announced the result of his investigations in the French Academy of Sciences.

The slime was richly intermixed with the remains of the skins and bristles of animals, but otherwise consisted mainly of a mixture of sand and water. Bacteria cultures were obtained from it with comparative ease, and consisted principally of the coli bacillus and of various species of the sphaero-bacteria, both of which are so frequently found in animals. The question now is: How can the presence of these bacteria at such great depth (the slime experimented with was taken at a depth of ten meters under the surface of the ground), be explained, after the generally accepted experience that even at two meters under the surface, the ground is usually almost entirely germ free.

As an initial theory, we might be led to think that the bacteria, in consequence of bad filtration, had forced their way into the inner parts of the grave from the upper strata, that is, from the surface. However, owing to the geological condition of the entire surrounding country, this theory must be excluded altogether, and we must accept it as certain that the bacteria do in fact find their source in the goat, dog, and cow carcasses found in the grave. That there is nothing improbable in itself in this assumption, lies in the fact that the appearance of the so-called "retarding life," is long and well known in bacteriology. Many species of bacteria are able to maintain life for an abnormally long period on a ground which offers them no nutritive material whatever; when, however, they are transplanted into more favorable nutritive mediums, they again begin to reproduce. The bacteria now under consideration, seem to furnish a case of this state (though, to be sure, an extraordinarily long one), of the "retarded life." They have evidently been imbedded into the slime of this grave nearly eighteen hundred years without suffering a loss of their vigor and vitality.

* Translated for Pure Products from Tageszeitung für Brauerei.

ROPE DRIVES—VARIOUS METHODS OF ARRANGING ROPES ON THE SHEAVES.*

By R. HOYT.

THERE seems to be considerable difference in opinion regarding the various ways of applying rope to the sheaves in rope driving, viz., multiple- or separate-rope system, continuous-wrap or single-rope system with the rope from one of the grooves running on a traveling take-up device, continuous-wrap or single-rope system with the take-up working directly on all the wraps.

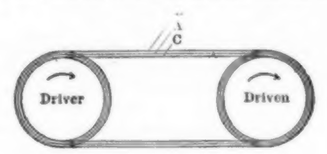


FIG. 1

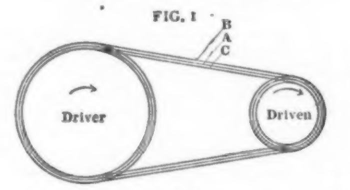


FIG. 2

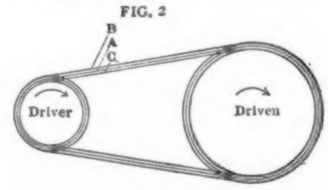


FIG. 3

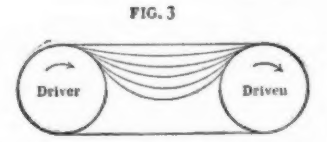


FIG. 4

The multiple- or separate-rope system on a horizontal drive where the distance between centers is great enough so the weight of the rope will give the required tension, having the tight or pulling part on the lower side and the sheaves of the same diameter, as in Fig. 1, should be very satisfactory, as old or worn ropes may be replaced by new ones of larger diameter or some of the ropes may be tighter than others and still not alter the efficiency of the drive. It will be noticed in this case that a larger rope does not alter the proportional pitch diameters of the rope on the driving and driven sheaves; but if one of the sheaves is larger than the other, as in Figs. 2 and 3, and a new or larger rope is substituted for a worn or smaller one or if some of the ropes are a great deal tighter than others, a differential action will be produced on the ropes owing to the fact that the larger or slack rope will not go as deeply in its grooves as the smaller or tight one, and consequently the proportionate pitch diameter on the rope on the driver and driven sheave will be changed. The action will depend upon whether the large or small sheave is the driver. If the driver is the largest and of course assuming the slack or large rope is weaker than the combined tight or smaller ones, then it will have less strain on the pulling side; but if the driver is smaller, then the new or large rope will have greater strain on the pulling side. Whether the driver is larger or smaller, a large or slack rope affects the action oppositely to a small or tight rope. Fig. 3 shows how the action is reversed from Fig. 2.

For clearness we will exaggerate the differences in diameter in the sketches and figure the speeds that the different size ropes would produce. We will take *A* as normal, *B* 1 inch farther out of the groove, producing a difference in diameter of 2 inches; *C* 1 inch

* Power.

deeper in the groove, producing a difference in diameter of 2 inches. In Fig. 1 assume for the normal diameter of driver and driven 40 inches, and 42 inches for B and 38 inches for C, with a speed of 200 revolutions per minute for the driver. Either A, B, or C will give 200 revolutions per minute for the driven sheave, omitting slippage, of course. In Fig. 2, say the normal diameter of the driver for rope A is 60 inches and of the driven 30 inches, a speed of the driver of 200 revolutions per minute will give the driven sheave a speed of 400 revolutions per minute; B, with the driver 62 inches and the driven sheave 32 inches diameter, will give the latter a velocity of 387½ revolutions per minute. With C the driver is 58 inches, the driven 28 inches, and the speed given the latter 414 2/7 revolutions per minute. In Fig. 3 the normal diameter of the driving sheave being 30 inches and the driven 60 inches, a speed of the driver of 200 revolutions per minute will give a speed of the driven member of 100 revolutions per minute. With B, if the driver is 32 and the driven 62 inches, the driven sheave will have a speed of 103 7/31 revolutions per minute; C, with the driver 28 inches and the driven sheave 58 inches, will give the latter a speed of 96 16/29 revolutions per minute. So it will be readily seen what effect a large or small rope would have.

There are some who claim that slack ropes will transmit more power owing to more wrap on the sheaves, while others claim that tight ropes are better. I think if one had a drive and the ropes were all slack and they were troubled with the ropes slipping, the first remedy they would try would be to tighten the ropes. But, if the conditions were like Fig. 3, I don't see that it would be particularly harmful to have some of the ropes longer than others; in fact, it might be well, as the longer ropes would not make a complete circuit as quickly as the shorter ones; consequently the position of the splices would be continually changing. However, it seems more natural, and I should consider it best, to have about the same pull on all the ropes, that is, not have them as shown in Fig. 4. In conclusion for the system, it should be noted that it has no means of tightening the ropes except by resplicing; it is not as well adapted to various conditions as the other forms; it is the cheapest form to install and in some cases should give excellent satisfaction.

With the continuous-wrap system having the rope from one of the grooves pass over a traveling take-up, the latter has a tendency to produce an unequal strain in the rope. In taking up, or letting out, the rope must either slide around the grooves, or the strands having the greatest pull will wedge themselves deeper in the grooves, producing a smaller pitch diameter than the ones having less pull, making a differential action on the ropes. It is, therefore, probable that it is the differential action that takes up or lets out the ropes, the take-up merely acting in a sense as an automatic adjustable idler. In tightening, when the rope stretches, or dries out, or even in running normal, the greatest pull will be near the take-up, but if the drive is exposed to moisture, and the rope shortens, it will be farthest from the take-up, depending proportionately on the number of grooves the take-up controls; so in large drives it is best to have more than one take-up.

If one should use an unyieldable substance, as, for experiment, a plain wire on two drums wrapped a number of times around and also over a take-up, and the drums were moved together or apart, he would find that the wire would have to slide around the drum; but, of course, with a rope in a groove it is different. The rope will yield some. It will also go deeper in the groove. This system costs more than the preceding form, owing to extra expense for the traveling take-up, but may be applied readily to different conditions, and will be quite satisfactory in general, if properly designed and installed.

The continuous-wrap system with a take-up or tightener acting directly on all the wraps has practically none of the objectionable features mentioned in the other two forms, and is quick in action, making it applicable where power is suddenly thrown on or off. If the tightener is made automatic, it may be controlled in numerous ways, as with a weight or weight and lever or tackle blocks and weight, etc. It also may be fitted with a cylinder and piston, with a valve to prevent too quick action if power is suddenly thrown off or on. There is ordinarily practically no unequal strain on the rope. This system may be applied to different conditions as readily as the preceding form. Its cost is more than that of either of the others, as the tightener must have as many grooves as there are wraps. It must also have a winder to return the last wrap to the first groove, and to give its highest efficiency it must be properly designed and installed.

In either of the continuous-wrap systems, if a portion of larger rope is used, it will produce a greater strain directly behind the large rope, owing to its traveling around the sheave quicker. In angle work there is always extra wear on the rope in the side of the groove, as only the center or one rope may be accurately lined; so it is not advisable to crowd the centers in angular drives, as the shorter the centers and wider the sheaves the greater the wearing angle. It must be remembered that the foregoing applies to ordinary simple drives as shown in the sketches; where the drive is complicated, it may be necessary to make other allowances.

Good material should be used and competent parties employed for designing and installing rope drives. Don't be hasty to condemn a drive in general because of a poor rope, a flow in a sheave, or because of its being erected in an unworkmanlike manner.

ELECTRICAL NOTES.

An inventor has devised an electrical machine for bleaching flour, thereby imparting that palatable-looking whiteness to the foodstuff. There is a small closed chamber containing an electric arc of great length and at high voltage. While the arc is struck a current of air is forced through the chamber, and coming into contact with the flame is burnt, being then passed through the flour as an agitator and bleaching the powdered cereal in the process. Apparently under the influence of the electric arc the air becomes resolved into compounds of oxygen and nitrogen, which are thereby converted into powerful bleaching agents. It will be seen that this system is essentially different from the ordinary electrical whitening process, in which the air is not burnt, but is ozonized in a chamber containing a silent electric arc. The former method, however, is stated to be cheaper and more successful than that already in vogue.

A report was submitted recently by George Nicolaus to the telegraph section of the Elektrotechnischen Verein, dealing with the testing of small motors such as are used in telegraph and other similar work. The dynamometer is of the air-vane type, and consists simply of a split sleeve which may be slipped over the end of the motor shaft and clamped in place. The outer end of this sleeve carries a rod at right angles to the motor axis, which forms arms upon which are placed two circular disks fitted with clamps for holding them in any position on the two arms. Definite positions are marked on the arms, and by means of curves the power developed by the motor with the vanes in any position and at any given speed can be read off directly. The dynamometer is calibrated by means of a cradle dynamometer, upon which the test motor is placed. The apparatus is simple and gives a steady load, besides being cleanly and easy to control. —Electrical Review.

Messrs. Sidney Leetham and William Cramp, of Manchester, read a paper on the "Electrical Discharge in Air and its Commercial Application." When experimenting with the sterilization and bleaching of flour by ozone, they stated, Mr. Leetham observed in 1903 that a much more powerful bleaching agent than ozone was produced if the ozonized air was afterward passed through boxes in which electrical discharges between spark-points were taking place. Prof. H. E. Armstrong had ascribed the improved effect to the presence of nitrogen oxides. The authors perfected their apparatus, which now consists of a compact steel plate case containing alternator, transformer, ozonizer, and spark-box, the latter two in series on the secondary circuit. The air is supplied by a small Root blower, filtered, ozonized, exposed to sparks, and sent through a valve flange straight to the reel-box through which the material to be bleached is passing. With a feed of 100 cubic feet per minute, the resulting gas contained in 40,000 parts (by volume) of air, 3 parts of ozone, and 1 part of oxide of nitrogen. The temperature, air velocity, pressure, current frequency, and wave form, the number, shape, and distance of the spark-points, all have their influences. As long as the air resistance is high, ozone is the chief product; when the resistance breaks down, nitrogen oxides appear, which, contrary to many authorities, can exist side by side without mutual destruction. The bleaching appears to be an oxidation process; about two-thirds of the micro-organisms contained in flour are destroyed, and the treated flour seems to absorb more water than untreated flour.

The Siemens & Halske firm of Berlin are now manufacturing a dry battery of a new type, which is intended to replace the preceding batteries and is claimed to be an improvement. It is known as the "T" type. The new battery when put upon short circuit after remaining standing for a year, was able to give 12 amperes current and worked very well. A comparison which was made by the Physico-Technical Institute of Charlottenburg between the new battery and the Hellesen dry battery, one of the best of the preceding types, showed the following results as to the capacity in ampere hours: The weight of the new battery is 1.5 kilogrammes, and the dimensions are 7 by 3 by 3 inches. On the test the first discharge was made at the rate of 0.1 ampere. Here the Hellesen battery showed 46.8 to 47.1 ampere hours, while the "T" battery gave 65.3 ampere hours, which is quite in its favor. The second test was made by discharging the batteries through (a) a resistance of ten ohms and (b) through twenty ohms. For the Hellesen and the new batteries respectively we have 54.3 to 61.1 ampere hours and 84.3 to 82.7 ampere hours for test (a). On test (b) the cells showed 69.8 and 109 ampere hours. Thus it is seen that the Siemens & Halske cell has a yield of about forty per cent above what the Hellesen battery gives. On the other hand, it is found that the cells are more uniform in capacity and are able to recuperate more rapidly. The exact arrangement of the interior of the cell has not yet been made public.

A paper written by D. L. Lindquist, which described the two or more phase magnet, appeared in the Electrical World. It is shown that the pull is constant at any instant, and that the resultant pull is always exerted through the axis of the magnet, thus preventing rocking and consequent chattering. The power-factor of a certain magnet is practically independent of the length of air-gap, but with increased air-gap, the losses in the core increase very considerably. In order to get the maximum pull the air-gap must be in the center of the coil. A polyphase magnet should never be loaded to such an extent that the load exceeds the minimum instantaneous pull of the magnet. A magnet will commence to be noisy at about one-half full load, but will in general hold without noise all the load it can lift, so long as the length of motion is not too short. The paper is largely illustrated with curves. In the second part, the influence of coil resistance and also of external resistance is investigated; the former was before taken as negligible. It is illustrated with curves from the test of a two-phase magnet supplied with two-phase current, and with several vector diagrams, showing the allowance that must be made for the resistance of the magnet coils at zero air-gap and ¼-inch air-gap, also when an external resistance is in series with the magnet. It is shown that in general neither resistance nor inductance of a fixed amount can be used for regulating the voltage in an alternating-current magnet, unless used in conjunction with a switch for inserting more resistance or inductance after the magnet has lifted its load. It is also shown that an alternating-current magnet has a starting pull depending on the instant at which the circuit is closed, and that under the most favorable conditions this maximum starting pull may be four times the maximum pull after equilibrium has been established; since, however, it is uncertain at what moment the circuit may be closed, the possible or probable starting pull cannot be counted on. The magnet can naturally only be used to do work when the necessary lifting force is less than the effective pull of the magnet; and if the current is left with the cores apart the magnet is liable to become overheated due to too great a current on account of the inductance being too small. The high starting pull often causes the magnet to lift very quickly, thereby causing a hard blow when the cores meet; to avoid this it is necessary to arrange the magnets with dashpots.

SCIENCE NOTES.

It has been decided to carry out careful and thorough excavation of the site of the ancient Roman town near Corbridge, about eighteen miles distant from Newcastle in the north of England. This country is particularly rich in Roman remains, many important military stations having been established in this district to repel the invasive tactics of the Picts from across the Scottish border. The present site is believed to be the remains of Corstopitum, an old market town built by the Romans. It differs materially from the surrounding military encampments. It is anticipated that discoveries of great value from an archæological point of view will result, since already many interesting relics have been found upon the site. The excavation work is to be carried out by an influential committee, of which the Duke of Northumberland is the president, and the work will occupy some five years.

Owing to the large number of fires that have occurred within the past few months upon vessels engaged in carrying wool from New Zealand to England, the causes of which have been somewhat mysterious, the government of the Australian colony has appointed a commission to investigate the liability of wool to spontaneous combustion. In this direction some striking evidence has been offered. Upon the arrival of two bales of wool at Wellington from a station near Hawera, conveyed in a steel truck, signs of overheating were observed. The truck with its contents was thereupon sidetracked and a vigilant watch maintained. The heating was found to increase until at last one of the bales commenced to steam. The bales were thereupon secured by the commission and removed to a more convenient point for closer observation, since it is expected that in time they will burst into flame, thereby conclusively showing that wool is subject, when stored and carried under certain conditions, to spontaneous combustion.

The government of New South Wales are engaged in experimenting with the bacteriological treatment evolved by the French scientist, Dr. Danysz, a professor at the Pasteur Institute, for exterminating rabbits. Owing to the ravages and enormous damage inflicted to the crops by this pest—despite the large and increasing trade that has developed in exporting frozen rabbits to the European markets for consumption, their numbers are still rapidly increasing—the farmers subscribed a sum of $50,000 to enable Dr. Danysz to visit the colony and carry out investigations upon the spot with his process. This scientist claims to have discovered a microbe which though fatal to the rabbit is perfectly innocuous to other animals and human beings. A number of tubes containing the bacteria were taken by the professor to New South Wales, but upon his arrival the bacteria were promptly impounded by the Australian quarantine authorities. It was considered too dangerous to permit the professor to carry out his investigations at random, owing to the speculative nature of his discovery, so he has been isolated upon Broughton Island, where the necessary facilities were provided, together with the services of the government expert. Consignments of rabbits are dispatched weekly together with other animals to the professor's quarters, where he is engaged upon his experiments to demonstrate the innocuous nature of his microbe to aught but the rabbit. Directly his contentions have been conclusively proved, Dr. Danysz will be permitted to continue his investigations upon the mainland.

There can be no permanent advance for any people except it is based on the Gibraltar of technical education. The education of the people is the building up of the nation. There should be less education for intellectual gymnastics and more training for useful-

ness; less of the older idea of the three R's for all, with high culture for the wealthy, and more attention to the systematic instruction of the people in the work of the people. We should estimate rightly the value of the industrial unit—the man—and make him as efficient as possible, as a man, as a citizen, and as an industrial producer. The relations which the technically trained man will bear to the great political and industrial changes are many and important. The coming era of industrial regeneration will be the result of a more accurate knowledge of science and a closer application of its principles; the engineer will be the missionary. The mechanic, the trained artisan, the technical man, and the scientific farmer will be the pioneers. The warfare of the future will be industrial and political, rather than military. Already we see the signs. The barbarous idea of depicting conquered lands or dependent colonies for the benefit of the conquering nation is yielding to the more civilized idea of internal improvements, with material advantages to both parties. Because Spain plundered her colonies and refused to advance with the age of science, she is no longer a factor in Western civilization. The world will become an industrial battlefield. The diplomat will become more and more a high-grade commercial agent; the military leader will be a preserver of law and order, rather than a destroyer of life and property; and the engineer will be their chief executive in adapting the forces of nature to the convenience of man. The great change in economic and industrial life of the twentieth century will be the work of the engineer.

ENGINEERING NOTES.

It is apparently a mistake to regard any kind of combustible matter as having no value. There are, of course, cases, especially in a new country with undeveloped fuel resources and desert districts, where that value is not immediate and practical. There is so much being said just now about the realization of ideals in industrial pursuits that it is surprising to find in the conservation of fuels no trace or effect of such doctrine. All power plants are designed with the ultimate object of being producers of wealth for the present owners and with no regard for future activities. But even when guided by purely material motives, it is well to remember that the valuation of property is subject to great fluctuations brought about by the rapid expansion of industries and the development of new branches.

Another interesting relic of George Stephenson, the inventor of the locomotive, is about to disappear. The bridge which was built over the River Tees, near Thornaby, for the Stockton and Darlington Railroad in 1841, and which after the absorption of this pioneer road by the North-Eastern trunk railroad was retained, is now to be removed, owing to the exigencies of heavier and greater traffic. The old structure is built up of cast-iron girders strengthened by wrought-iron tension straps, and carried by masonry piers which rest on piled foundations at about low-water level. The new bridge is to be of the three-girder type with rolled steel joists and heavy sectional steel work, designed by Mr. W. J. Cudworth, the chief engineer to the southern division of the North-Eastern Railroad.

Arrangements have now been concluded for carrying out the construction of the railroad up the Matterhorn. In 1892 two Zurich engineers secured the concession from the Swiss Federal government to build a railroad to the summit of the mountain from Zermatt, and also another line from the latter point to the crest of the Gornergrat. The Matterhorn project is to be completed in four years, and will cost approximately $1,250,000. It is to be built upon the well-known cogwheel system, and will be in two sections. The first will extend from the Viegé station at Zermatt to the Matterhorn hut, while the second will be from the hut through a tunnel about 7,650 feet in length to the summit of the mountain. The upper terminus will be built within 60 feet of the summit, and a number of rooms are to be provided cut out of the solid rock. Among other facilities that are to be provided will be a special chamber filled with compressed oxygen for the benefit of tourists suffering from mountain sickness. The journey will occupy about one and one-half hours, and the tariff will be $10. Construction is to be commenced next summer.

An interesting experiment is being made on the Santa Fé with a decapod locomotive having simple cylinders 32 by 32 inches, carrying a boiler pressure of only 140 pounds. The engine was built at the Baldwin Locomotive Works and is fitted with a smoke box superheater, which is intended to superheat the steam about 100 deg. F. The proportions of the cylinders are such as to develop the full tractive power and utilize all the adhesion due to the weight on the drivers. The patterns from which the cylinders were cast are those used for the low-pressure portions of the cylinders for tandem compound engines having 19 by 32 inch high-pressure cylinders, but modified to suit the requirements of this experiment. The locomotive is intended for service in a bad water district, and it was expected that the low pressure would overcome difficulties due to leaky tubes and firebox seams and other boiler trouble which are aggravated by high-pressure steam when the water is bad. The superheater was added to prevent condensation in the large simple cylinders and to make up for the slight loss in economy due to low pressure steam. The engine is being carefully tested and the results will have special interest as the cylinder proportions and pressures are so widely different from present standard practice.—Railway Age.

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TABLE OF CONTENTS.